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JET NOISE SUPPRESSOR NOZZLE DEVELOPMENT FOR AUGMENTOR WING JET STOL RESEARCH AIRCRAFT (C-8A BUFFALO)

D.L. Harkonen, C.C. Marrs, J.V. O'Keefe

December 1974

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Jet Noise Suppression Nozzle

Development for Augmentor Wing

Jet STOL Research Aircraft (C-8A Buffalo)

by

D.L. Harkonen, C.C. Marrs, and J.V. O'Keefe

page 13: Symbols and Abbreviations

Should read:

$N_H/\sqrt{T_1}$ - corrected engine high pressure compressors rotor speed, rpm $/\sqrt{°K}$

T_1 - engine inlet total temperature, °K

V_1 - fully expanded jet velocity, m/sec or (ft/sec)

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16. Abstract

This report is the third and final report covering the Augmentor-Wing STOL Research Aircraft (C-8A Buffalo) Jet Noise Reduction Program.

Noise and performance test results are presented for a full-scale advanced design rectangular array lobe jet suppressor nozzle (plain wall and corrugated). Flight design and installation considerations are also discussed. Noise data are presented in terms of peak PNLT (perceived noise level, tone corrected) suppression relative to the existing airplane and one-third octave-band spectra. Nozzle performance is presented in terms of velocity coefficient. Estimates of the hot thrust available during emergency (engine out) with the suppressor nozzle installed are compared with the current thrust levels produced by the round convergent nozzles.

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SUMMARY

The original full scale rectangular array lobe suppressor nozzle (BNS-1), described in references 1 and 2, was modified by converging and corrugating the nozzle lobe walls and was tested statically to determine the acoustic and thrust performance. The tests were conducted on the Boeing acoustic/ thrust test facility (figs. 1 and 2) in April 1974. The nozzle, blocked down in exit area to match the airflow capacity of the test facility, was modified to represent, as much as possible, the final flight design configuration, i.e., lobe width, length, spacing, ramp angle, and internal strut fairings.

The two modified lobe wall designs tested, known as BNS-3, were (1) the convergent tip plain wall (fig. 3) and (2) a corrugated wall (fig. 4). Both had seven lobes flowing. The BNS-3 plain wall nozzle produced tones similar to those produced by the original BNS-1 lobe nozzle described in reference 2. Techniques that were employed to eliminate the tones are described in the text.

Tests of the BNS-3 corrugated lobes were successful in that no tones were found to exist and a worthwhile amount of noise suppression was realized. The peak sideline PNL levels versus nozzle pressure ratio measured with the BNS-3 nozzles (plain and corrugated) and with the original BNS-1 plain lobe nozzle design are presented in figure 5. As evident in figure 5, the corrugated nozzle design produces large amounts of suppression (4 to 6 PNdB) through the full range of pressure ratios and jet velocities. Also, the additional mid-frequency attenuation brought about by the corrugated lobe ends has a very influential effect on PNL values at close distances such as the 152 m (500 ft) sideline.

The noise spectra produced by the nozzles at a pressure ratio of 1.5 show that the BNS-3 plain convergent nozzle* produces some tones, although not as strong as the original BNS-1 nozzle, and that the BNS-3 corrugated nozzle is tone free and effectively suppresses the noise in the low and mid-frequency bands. The peak PNLT noise suppression produced by the plain and corrugated lobe nozzles relative to the airplane conical nozzles at three distances and two power settings are presented in figure 6. As indicated, the corrugated design will meet or surpass the noise target values established prior to test.

The effect of corrugating the BNS-3 convergent lobe nozzle on thrust performance is shown in figure 7. The corrugated walls, which represent a large increase in wetted perimeter, produce a 3% loss in velocity coefficient or thrust loss. Hot thrust considerations on the C-8A Buffalo aircraft are only important in the event of an engine-out situation. The effect of the corrugated suppressor nozzles on aircraft hot thrust performance can only be estimated by making comparisons with the

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*This nozzle configuration has equal length lobes. Acoustic effects due to cutting back alternate lobes are discussed in tone control section.

existing airplane conical nozzle thrust levels using the same reference (charging station). The absolute levels of velocity coefficient (C_V) shown are referenced to the conditions at the entrance to the lobes. The hot thrust levels are compared using the same reference on figure 8. The charging station reference was estimated by adding estimated thrust vector, base drag, and friction losses to the measured hot thrust level extracted from measured test bed thrust data. Performance levels measured on the Boeing test stand are then comparable to the measured engine performance thrust levels. Also shown in figure 8 is the target minimum emergency thrust level required for adequate operational safety margins as established by NASA. A maximum of 890 N (200 lb) emergency thrust loss (per engine) is allowed in order to maintain the safety margin. As can be seen from figure 7, the C_V value obtained at emergency power setting as extrapolated from the measured data is 0.945 – a level that exceeds the emergency thrust requirement by approximately 1%.

Flight nozzle hardware design studies examined the tradeoffs in number and arrangement of nozzle lobes versus noise suppression, weight, thrust performance and fabrication costs. The final recommended design, a corrugated 13-lobe rectangular array suppressor is shown on figure 9. The tips of the lobes are corrugated and convergent in area. The lobe ramp angle is rather steep from the standpoint of secondary flow attachment but these external drag penalties are not significant on a low speed aircraft of this type. A more complete discussion of the flight nozzle design, including material selection, is included in appendix D.

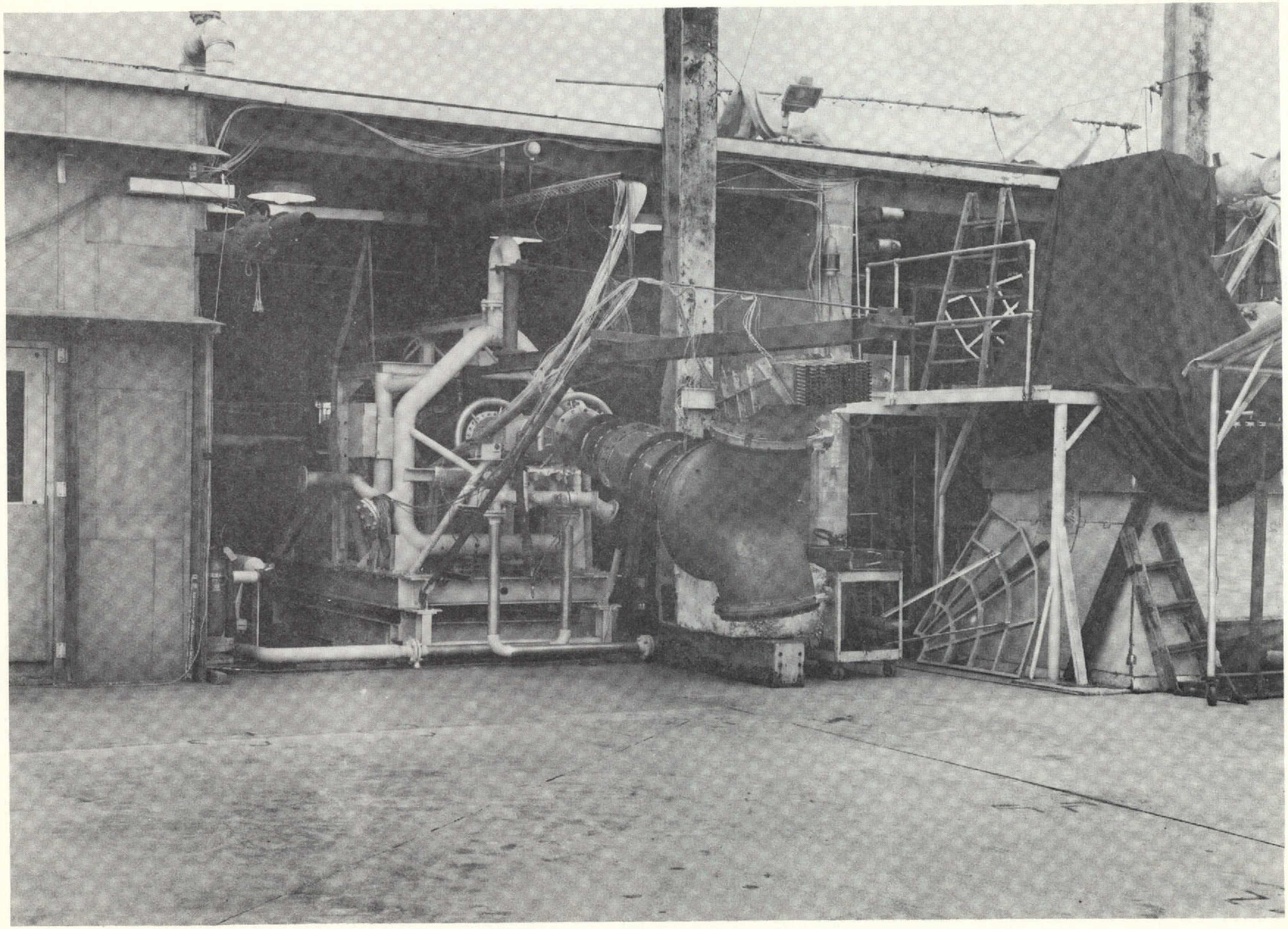


FIGURE 1.—BOEING ACOUSTIC/THRUST PERFORMANCE TEST FACILITY

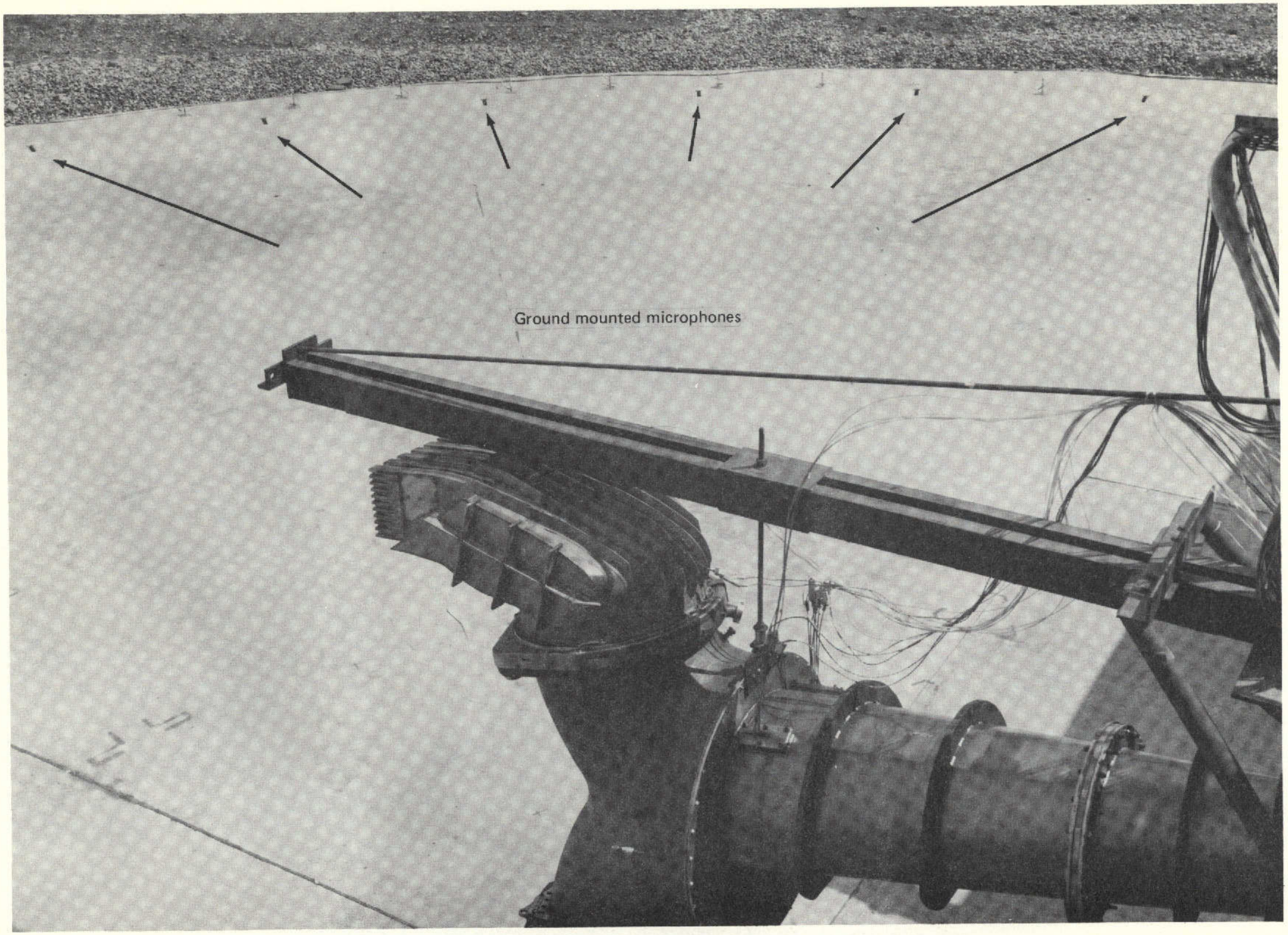


FIGURE 2.—TEST NOZZLE INSTALLATION AND ACOUSTIC ARENA

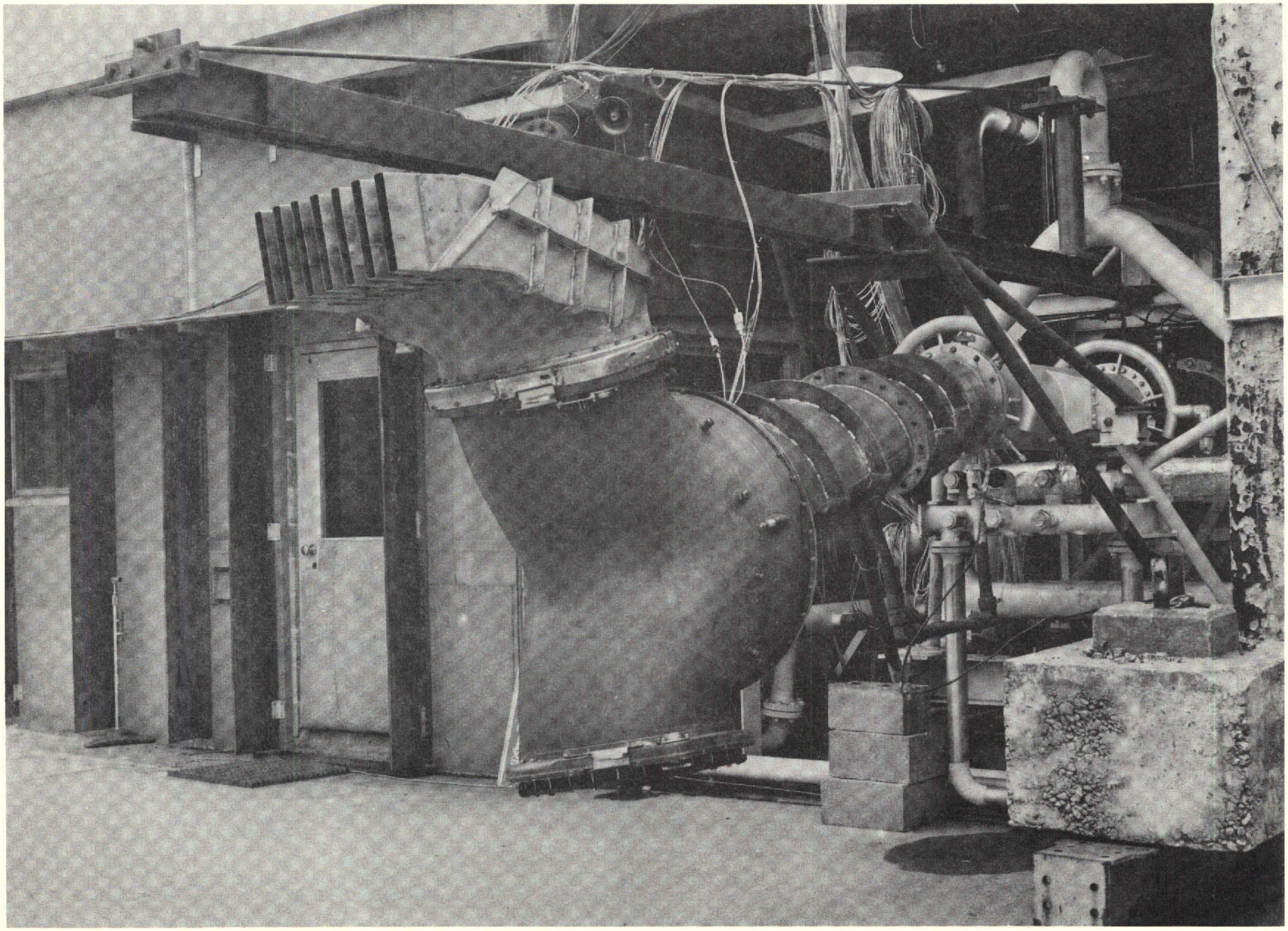


FIGURE 3.—BNS-3 LOBE NOZZLE WITH PLAIN CONVERGENT ENDS

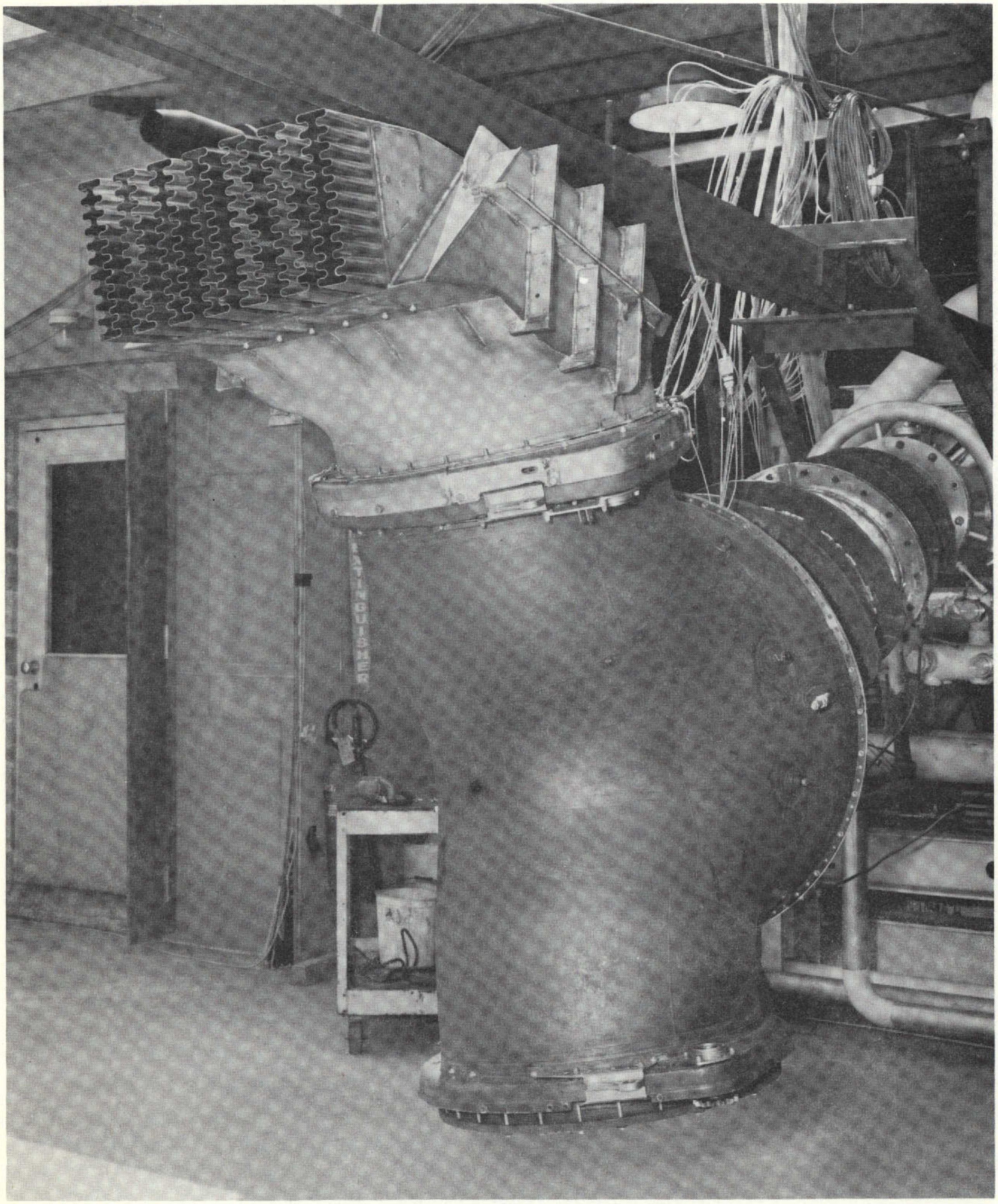
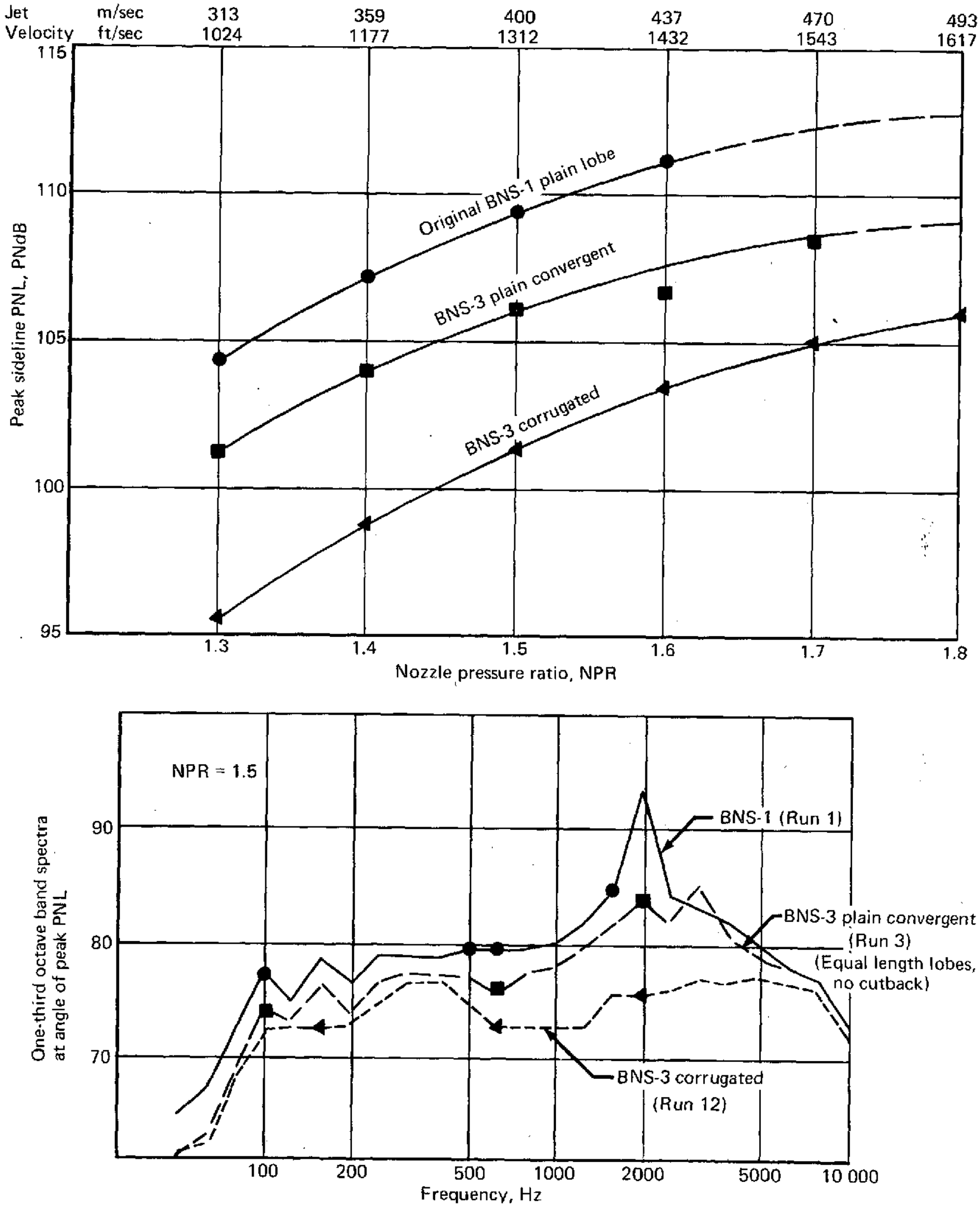
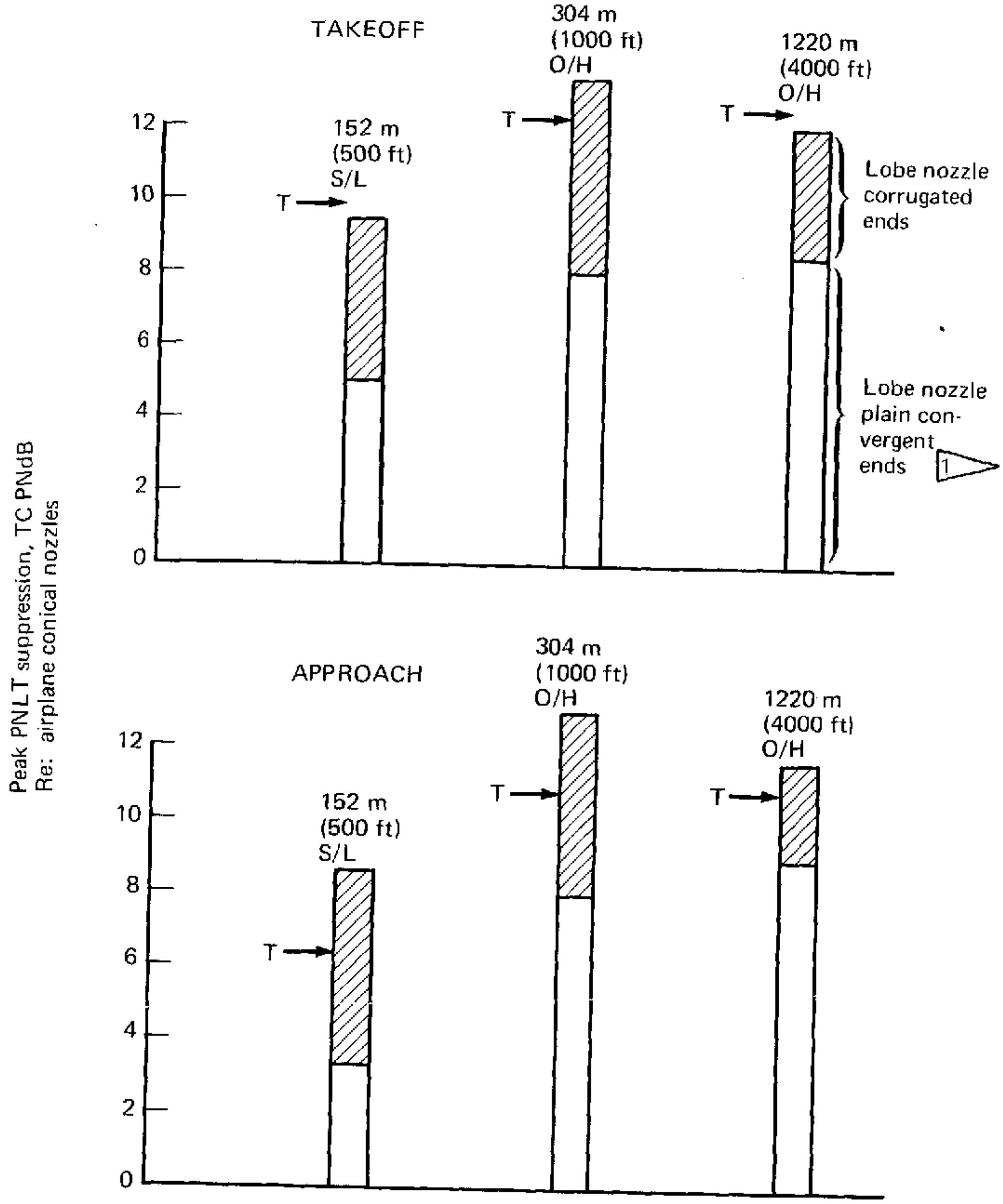


FIGURE 4.—BNS-3 LOBE NOZZLE WITH CORRUGATED CONVERGENT ENDS



*Test nozzle–exit area = 451.5 cm² (70 in.²)

*FIGURE 5.—152.4 m (500 ft) SIDELINE NOISE LEVELS**



T = target values prior to start of test

1 Includes directivity effect for rectangular array nozzles for O/H cases (ref. 2)

FIGURE 6.—INSTALLED JET NOISE SUPPRESSION LEVELS

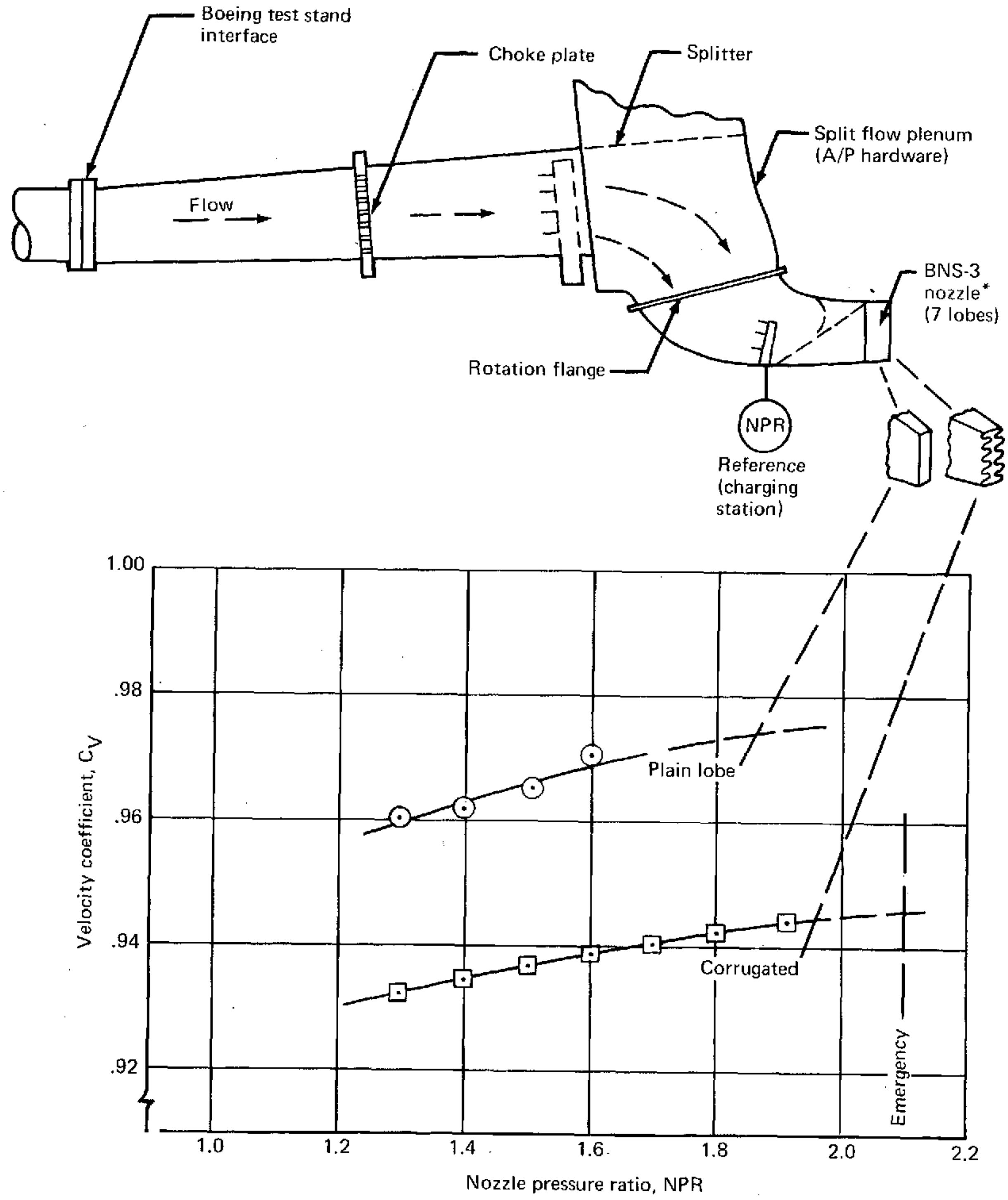


FIGURE 7.—THRUST PERFORMANCE OF THE BNS-3 PLAIN AND CORRUGATED NOZZLES

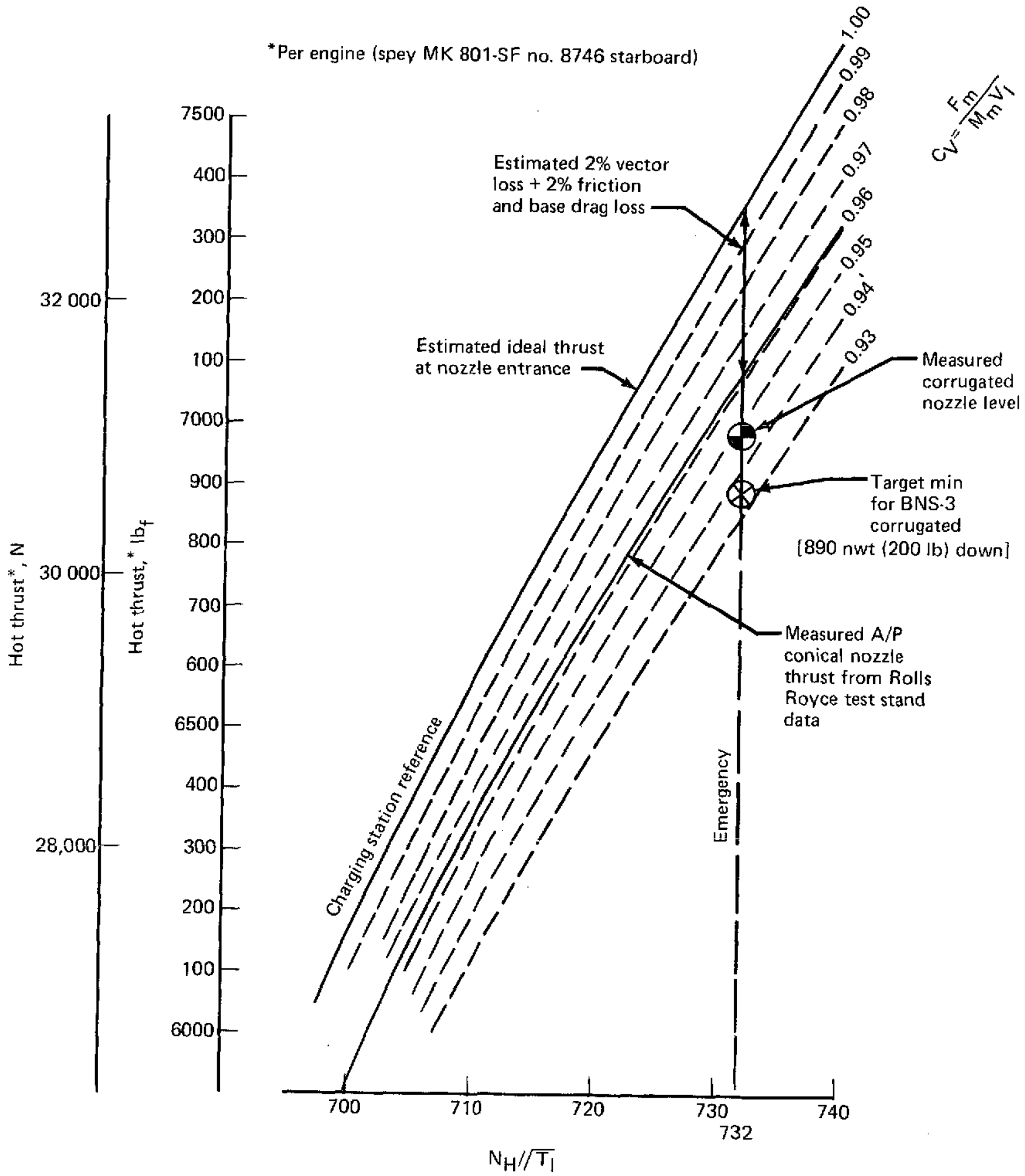


FIGURE 8.—A/P HOT THRUST PER ENGINE AND ESTIMATED PERFORMANCE REFERENCE

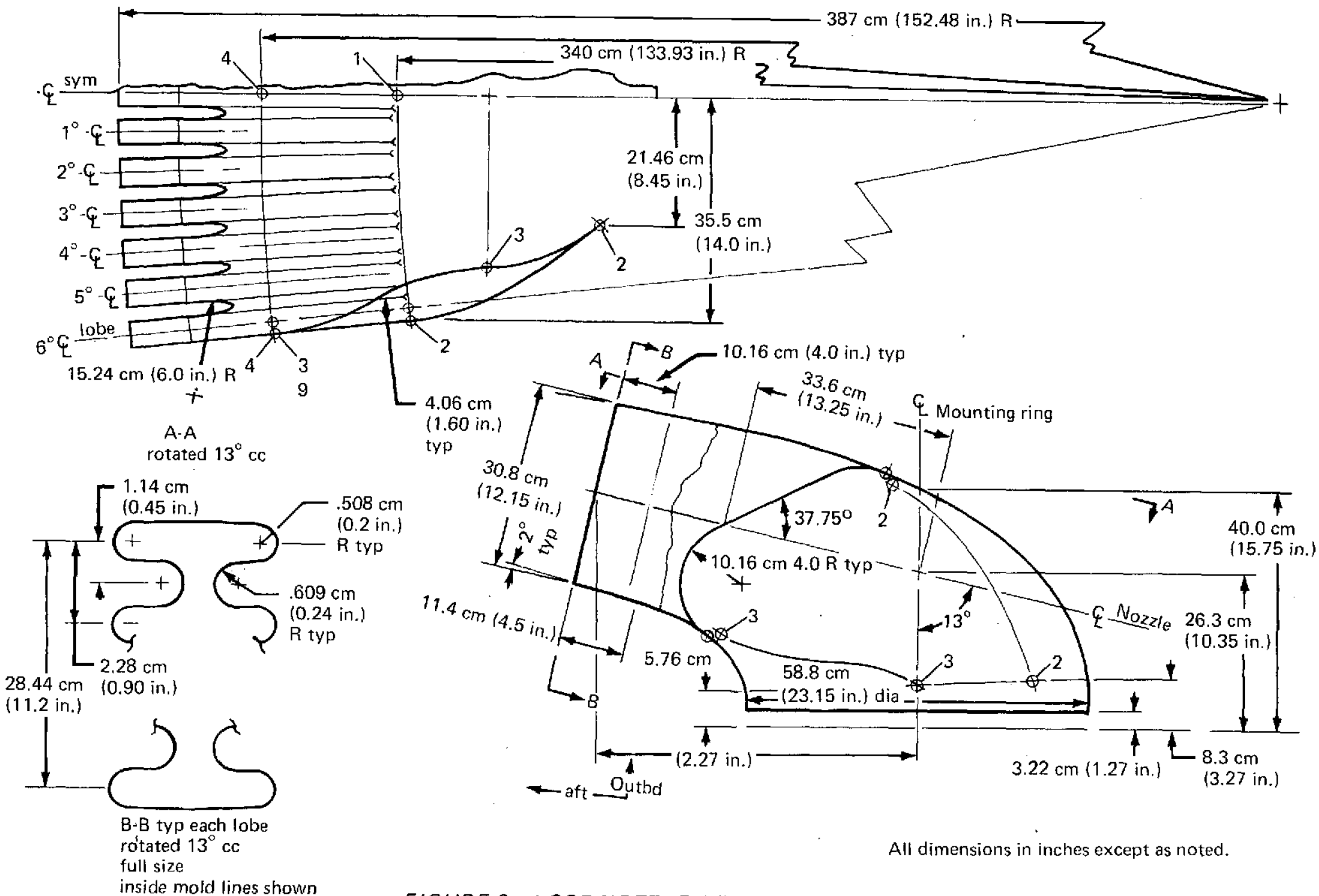


FIGURE 9.—LOBE NOZZLE GEOMETRY BUFF-03

INTRODUCTION

Static noise tests were conducted on the modified C-8A Buffalo augmentor wing jet STOL research aircraft in July 1973 (ref. 1) to examine means of reducing the jet noise levels produced by the Rolls Royce Spey mk 801 vectorable primary exhaust. While acquiring exploratory noise data, the effectiveness of jet noise reduction by use of over-area nozzles (engine derating) and a lobe-type suppressor nozzle was examined. The lobe suppressor nozzle was most effective but was hindered in acoustic performance because of a strong 2-kHz tone caused by the lobe nozzle. As reported in reference 2, the lobe nozzle was tested at one of the Boeing acoustic/thrust performance test facilities in January 1974. The 2 kHz tone was eliminated, and the thrust performance of the nozzle was measured.

Although elimination of the 2-kHz tone improved the noise suppression characteristics of the lobe nozzle, additional noise suppression was required to meet the original goal of 10-PNdB suppression. The additional suppression, however, must be acquired with minimum thrust and nozzle weight penalties. Analyses based on suppressor nozzle noise and performance design charts indicated that the noise suppression goals could be met within allowable thrust and weight penalties by use of corrugated nozzle walls. Before considering this design for flight installation, the noise/thrust trade-off must be confirmed by test and the structural requirements of the nozzle must be considered.

The third and final phase of this program involved fabrication and test of the modified nozzle walls (plain convergent and corrugated) while proceeding with a flight design.

Discussed herein are the measured noise and performance levels produced by the modified lobe nozzles and the implications the designs have on the aircraft noise and thrust performance levels.

SYMBOLS AND ABBREVIATIONS

C_V – velocity coefficient = $\frac{F_m}{M_m \cdot V_I}$

f – frequency, Hz

F_m – measured nozzle thrust N or (lb f)

M_m – measured mass flow, kg/sec, (slugs/sec)

$N_H/\sqrt{T_1}$ – corrected high speed engine rotor speed, corrected rpm, $RPM/\sqrt{^oK}$

NPR – nozzle pressure ratio of reference or charging station

O/H – overhead

PNdB – unit of perceived noise level

PNL – perceived noise level, PNdB

PNLT – tone corrected perceived noise level TC PNdB

S/L – sideline

SPL – sound pressure level, dB

STOL – short takeoff and landing

T – total gas temperature, ^oC or (^oF)

V_I – fully expanded jet velocity

DISCUSSION

TEST HARDWARE AND FACILITY DESCRIPTION

The hot nozzle facility, located at the north end of Boeing Field, is capable of airflows in the order of 20 kg/sec (40 lb/sec) at temperatures of 500°C (950°F). The interface duct at the exit of the facility is 30.5 cm (12 in.) in diameter. The transition adaptor that connected the facility interface to the SPEY split-flow plenum ("pants" section) was redesigned for this test to reduce the pressure distortions at the plenum entrance station that were evident during the reference 2 tests. Details of the redesigned transition and back pressure plate are shown in appendix A.

As the facility was to be used for testing only one nozzle, a splitter plate was installed in the split flow plenum so the flow would duplicate as much as possible the full-scale flow lines. The exit for the second nozzle on the plenum was blocked off at the rotation flange. Since airflow capacity of the test facility was not adequate to flow the nozzle exit area associated with the engine exhaust, only seven of the thirteen lobes planned for the flight design were tested. The BNS-3 test nozzle was created by modifying the original BNS-1 nozzle to alternately accept the seven plain convergent nozzle ends and the seven corrugated nozzle ends. Total pressure and temperature instrumentation were installed at the entrance to the nozzle lobes as shown in appendix A. This established a reference or charging station to which all performance levels discussed in this report are referred.

Preliminary flight hardware design studies indicate that for structural and manufacturing requirements, the floor of the nozzle and the individual lobe ramps should be joined with a large radius which would have some effect on the internal flow area progression. This was internally simulated by fabricating removable strut fairings, which are shown in the test configurations table in appendix A. Any performance effects due to this design could be determined by testing the BNS-3 nozzle with and without the strut fairings.

All modifications made to the plain lobe nozzles during the testing, i.e., fences, splitter, and exit cut back, are described in the Results section and in the test log (app. B).

The area surrounding the test facility is made up of smooth concrete and is ideal for ground surface mounted microphone installations (ref. 3). Nine microphones were located on a 15.2 m (50 ft) polar array, as measured from the nozzle exit plane and centerline. The microphones were located with the diaphragm 1.27 cm (0.5 in.) above the concrete surface, at angles of 90°, 100°, 110°, 120°, 125°, 130°, 135°, 140° relative to the inlet (see app. A).

RESULTS

Acoustic and performance tests conducted at Boeing on one of the lobe-type jet suppressor nozzles (BNS-1), described in reference 1, demonstrated that a strong tone at approximately 2 kHz could be eliminated by altering the conditions of the gas mixing region aft of the lobe exit plane. Further evaluations were required with modified lobe designs so that the full acoustic potential of the rectangular array lobe nozzles could be realized.

Additional suppression was determined to be available analytically with minimum thrust penalties by use of convergent, corrugated ends on each lobe. As a result of a design study to determine possible flightworthy configurations (app. D), the BNS-1 nozzle was modified to simulate these configurations.

Details of the alternations made to the BNS-1 nozzle to add new lobes and internal fairings are described in appendix A. The nozzle was designated BNS-3 following completion of the alternations. The test plans that describe the test rig, modified transition and choke plate installation, internal pressure and temperature rakes, and acoustic arena layout are also included in appendix A. A discussion of the acoustic and propulsion performance results obtained from this test follows.

The test nozzle configurations will be discussed in the following sections in generally the chronological order in which they were tested.

ACOUSTIC ANALYSIS

Each configuration was tested through a pressure ratio range of 1.3 through 1.6 with selected configurations tested up to 1.8 NPR. The total air temperature was set at 399°C (750°F) at 1.3 NPR and increased in 28°C (50°F) increments with each 0.1 increment in pressure ratio.

Plain Lobe Nozzles and Tone Control Techniques

The BNS-1 nozzle (figure 10) with seven lobes flowing (exit area = 595 cm^2 (92.4 $in.^2$) was tested from pressure ratios varying from 1.3 to 1.6. The main reason for testing this configuration was to acquire a current set of baseline acoustic data to be sure that the alterations in the transition/adaptor section had not changed the far-field noise spectra relative to past runs. The one-third octave-band data (figs. 11 through 19) show that the tone, found to exist in the reference 2 tests, was still evident.

The BNS-3 plain convergent design (figs. 20 and 21) with a 451 cm^2 (70 $in.^2$) exit area was designated configuration 2. Figure 22 is a narrow band analysis of configuration 2 at 1.4 and 1.5 NPR. The nozzle creates tones at 1900 Hz and 3300 Hz. Even though these tones are not of narrow band width, both frequencies will nevertheless add to a tone corrected perceived noise level (PNLT) calculation. Note that the higher frequency tone at 1.4 NPR is a slightly higher value than at 1.5 NPR. Further analysis at one-third octave band, figures 23 through 31, show that the 3 kHz tone tends to disappear as the NPR is increased. This tone is also directional and appears to be of little importance at the microphone angles near sideline. The lower frequency tone is more evident at the larger angles and increases as a function of nozzle pressure ratio.

It is obvious from an examination of the data for this configuration that some method of removing the tones is required in order to realize the full suppression potential.

Configuration 3 was identical to configuration 2 except for the addition of 2.54 cm (1 in.) fences attached at the exit of each lobe (see fig. 32). These fences were attached to one side of each lobe and extended 2.54 cm (1 in.) aft of the lobe exit plane. The fences were installed as a first attempt at eliminating the tones measured in Run 3 by possibly influencing the interaction of the gas streams from adjacent lobes. Narrow band analysis, figure 33, shows that very little was accomplished using this length of fence. One-third octave plots on figures 34 through 42 confirm the narrow band results.

Following the tests of the 2.54 cm (1 in.) fences, the fences were extended 12.7 cm (5 in.) in order to examine effects of the additional length. The 12.7 cm (5 in.) fence extensions are shown installed in figures 43 and 44. Acoustic results of this configuration are best shown by the narrow-band analysis on figure 45. The two tones evident from previous runs were eliminated, but a new tone of very narrow-band width has appeared at approximately 1500 Hz. This particular tone is about 15 dB above the background levels. It is interesting to see that by essentially extending one lobe wall, the tones created by the interaction between the adjacent lobes can be altered. The 1500 Hz tone shows up in the one-third octave data at all microphone positions (figs. 46 through 54).

Testing during the reference 1 tests showed that by adding a fence in the center of the secondary air stream between adjacent lobes, tones created by the nozzle could be eliminated. As the fences had been installed on the wall of each lobe for the above configurations with only partial results, it was decided to revert back to a previously successful method of installing the fences in the center of the secondary passages between each lobe. Figure 55 shows the fences (secondary splitters) installed.

The narrow-band analysis for this configuration (fig. 56) shows that at 1.3 NPR through 1.5 NPR tones at 2 kHz and 3.3 kHz existed and were quite strong. At an NPR of 1.6 the lower frequency tone disappeared and the 3.3 kHz tone was much reduced. The one-third octave-band

data (fig. 57 through 65) also confirm these results. Why this method of fence installation did not eliminate the tones as they did for the reference 2 test cannot be explained at this time and might be considered the subject for future research.

To eliminate the possibility that the 12.7 cm (5 in.) splitters were not quite long enough, one additional check was made with 10.3 cm (4 in.) extensions added to the 12.7 cm (5 in.) splitters. Only on-line data were recorded, and the results were the same as with the 12.7 cm (5 in.) splitters.

It was thought that any flow of the nozzle exhaust combining above and below the splitters might be allowing the tone mechanism to occur. So, 2.54 cm (1 in.) extensions were added to the upper and lower edges of the 12.7 cm (5 in.) splitters (see fig. 66). The narrow band spectra shown on figure 67 show a mixture of tones with little or no set pattern. The one-third octave plots on figures 68 through 76 show that on a one-third octave basis, the tone is produced at 2 kHz and is relatively consistent from 1.3 to 1.5 NPR. Above 1.5 NPR, the tones are considerably reduced.

Results from the previous configurations have shown that alterations in the mixing of adjacent gas streams aft of the exit plane can affect the acoustic tone characteristics. The fences tested here did not eliminate the tones as in the reference 1 tests but had a definite effect on the strength and/or the frequency of the tones. Another method of altering the conditions at the nozzle exit plane is to stagger the exit planes of the individual lobes. This was done by cutting back every other lobe 2.54 cm (1 in.) (figs. 77 and 78). Although the lobe nozzles are convergent, the small change in exit area that resulted from the cutback was not significant. Results of the narrow-band analysis are shown on figure 79. It is interesting that the tones generated by this configuration are quite broad-band, and only the 3400 Hz tone at 1.4 NPR is of considerable value. The tone at 2 kHz is not evident at 1.3 NPR, but as the power is advanced, this tone increases. On a one-third octave basis (figs. 80 through 88) the 2 kHz to 3 kHz frequency is the dominant part of the spectra at all measurement angles.

Corrugated Lobe Nozzles

Because limited test time prevented any further investigation as to the cause or elimination of the tones generated by the plain wall convergent lobes, the nozzle was removed to the shop to replace the seven plain lobes with seven corrugated lobes. The area convergence (lobe entrance/exit) of the corrugated lobes was identical to that of the plain lobe nozzles. The detailed dimensions of the nozzle are given in appendix A and the installed corrugated nozzle is pictured on figure 89.

The acoustic test results of this configuration are very impressive in that no tones were found to exist, and the low to mid-frequency suppression was very good. Figure 90 shows the narrow band results at the 115° microphone location. One-third octave analysis of the complete microphone

array is shown in figures 91 through 99. As can be seen from these figures, no tones exist at any directivity angle.

A comparison of the noise suppression characteristics of the corrugated nozzle versus the plain lobe nozzles is shown in the Summary section (fig. 5). The BNS-1 noise levels have been adjusted down to account for the larger exit area compared to the BNS-3 plain and corrugated nozzles. The breakup characteristics of the corrugated wall design provide good jet noise suppression even at low jet velocities of 306 m/sec (1000 ft/sec) at 152.4 m (500 ft) distance. The change in the noise spectra produced by the corrugated walls explains why considerable reduction in PNL (perceived noise level) was realized. The corrugated nozzle spectrum is tone free and attenuates much of the noise energy in the 1000 Hz through 5000 Hz bands. The peak frequency produced by the corrugated nozzle is around 8 kHz and by Strouhal relationship appears to be controlled by the dimension across each corrugation 1.27 cm (0.5 in.). The wavy walls of the corrugated nozzle also appear to interfere with or prevent the occurrence of the mechanism that is responsible for the tones that were produced by the plain wall nozzles.

PERFORMANCE ANALYSIS

The thrust performance produced by the test nozzles is presented in terms of velocity coefficient (C_V), which is the ratio of measured thrust to the ideal thrust at comparable mass flow conditions. Some mass flow leakage was evident around the split flow plenum nozzle rotation flange. This leakage was not easily controlled or measured and has the effect of lowering the velocity coefficient levels. Therefore, the C_V levels presented in this report are somewhat lower than the true level. The conditions at the lobe entrances are used as the ideal thrust reference or performance charging station. The physical position is shown in the summary sketch (fig. 7) and in the appendix A drawing.

Effects of Tone Control Devices on Thrust Performance

The initial attempts to control the undesirable acoustic tones produced by the BNS-3 plain convergent lobes consisted of two fence extension lengths attached to one nozzle lobe wall. An illustration of the fence installation along with the performance effects are presented in figure 100. The thrust loss due to 2.54 cm (1 in.) fences is not measurable but as indicated, the 12.7 cm (5 in.) fence length results in a 1% thrust loss. Because these tests were conducted primarily to obtain acoustic data, the fence attachment joint and fasteners were not as smooth as required for maximum propulsive performance.

In an attempt to duplicate the effectiveness of controlling the tones by the reference 2 test methods, fences were installed midway between each nozzle in the secondary passage extending 12.7 cm (5 in.) beyond the nozzle exit plane. A second step was to add 2.54 cm (1 in.) to the upper and lower edges of the fences. Although not conclusive, the C_V data presented in figure 101 indicate that the secondary fences lower the C_V by about 0.5% and the 2.54 cm (1 in.) high vertical extensions produce no measurable effect.

The last method tried in an attempt to control the tones produced by the plain convergent nozzles was to remove one in. from the exit of every other lobe. The method is illustrated and the performance effects are shown on figure 102. As expected, the lobe cutback does not result in any measurable performance penalty.

Performance Effects of Corrugated Walls and Internal Strut Fairings

The corrugated lobe nozzle was tested with and without the internal strut fairings. As indicated in figure 103, the strut fairings lower the velocity coefficient about 0.5%. Evidently, the increase in internal blockage caused by the strut fairings changes the internal flow acceleration and results in an increase in the internal friction losses.

The C_V performance levels for the corrugated lobes and the plain lobes are also compared in figure 103. The increase in wetted perimeter at the nozzle exit due to the corrugated walls results in 3% loss in velocity coefficient. Some of this thrust loss may also be due to the slightly divergent outer surfaces of the corrugations even though the flow area is constantly converging.

Installed Airplane Hot Thrust Performance Effects

The C-8A (Buffalo) hot thrust levels are mainly important in the event of an engine out situation. Any primary (hot thrust) jet suppressor that would be considered for installation on the aircraft must develop within 890 N (200 lb) of the hot thrust produced by the existing conical nozzles at emergency power so that adequate safety margins are maintained.

The objective of this program was to provide 10 PNdB jet noise suppression while maintaining adequate emergency (engine out) aircraft safety margins. Suppressor nozzle thrust levels can only be compared with existing thrust levels after establishing a common performance reference or charging station. Engine thrust measurements were never recorded while measuring the conditions at a convenient nozzle charging station such as at the entrance to the nozzle. This meant that the engine nozzle reference thrust level must be established by estimating the existing conical nozzle thrust losses and adding these to the measured thrust level. Based on high levels of total pressure distortion measured at the conical nozzle exit plane and probable flow separation, symptomatic of low discharge

coefficient levels (ref. 1) for a nozzle with this internal half angle, additional thrust losses due to thrust vector angle and base drag are certain to exist. The total thrust loss, which includes thrust vector, base drag, and friction, is estimated here at about 4%. The common performance reference level is thus established in figure 8 in the Summary. Then, from figure 7 in the Summary, the corrugated nozzle develops a velocity coefficient near 0.945 at emergency power (extrapolating to NPR = 2.1) and will meet the engine-out hot thrust requirement with some margin to spare. Some uncertainty exists in estimating the exact performance levels of the final flight nozzle design since the test hardware was not a complete simulation, and, as mentioned earlier, the uncontrollable leakage at the rotation flange tends to lower the measured C_V more for a blocked-down nozzle.

CONCLUSIONS AND RECOMMENDATIONS

1. Installation of corrugated wall rectangular array lobe nozzles in place of the existing Buffalo aircraft conical nozzles will provide 9-13 PNdB jet noise reduction at distances of 152.4 m (500 ft) to 1219 m (4000 ft) while maintaining emergency hot thrust performance within 890 N (200 lb) of the current level.

2. In the event that installation of the suppressor nozzles is desired, the following items should be reviewed before submitting the final design for fabrication:

   - structural considerations
   - detailed weight estimate
   - potential exhaust/augmentor flap jet impingement problem during emergency conditions

3. Acoustic tones that are produced by plain wall rectangular array lobe suppressor nozzles operating in certain ranges of jet velocity can be altered in strength and/or frequency by use of splitter/fence devices aft of the nozzle exit plane and by changing the geometry at the exit.

4. Studies oriented to understanding the exact mechanisms responsible for the acoustic tone generation experienced with plain lobe suppressor nozzles should be undertaken.

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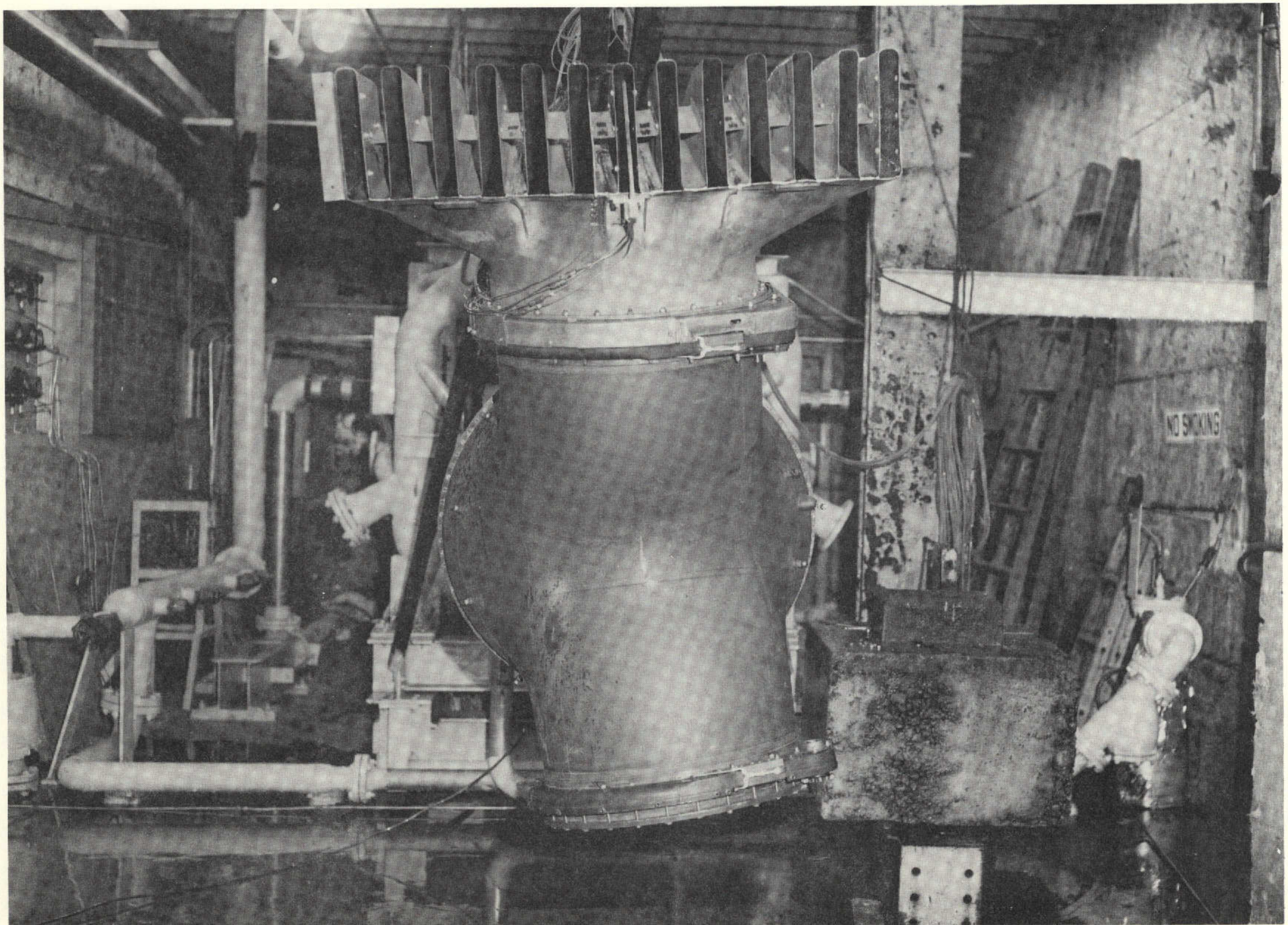
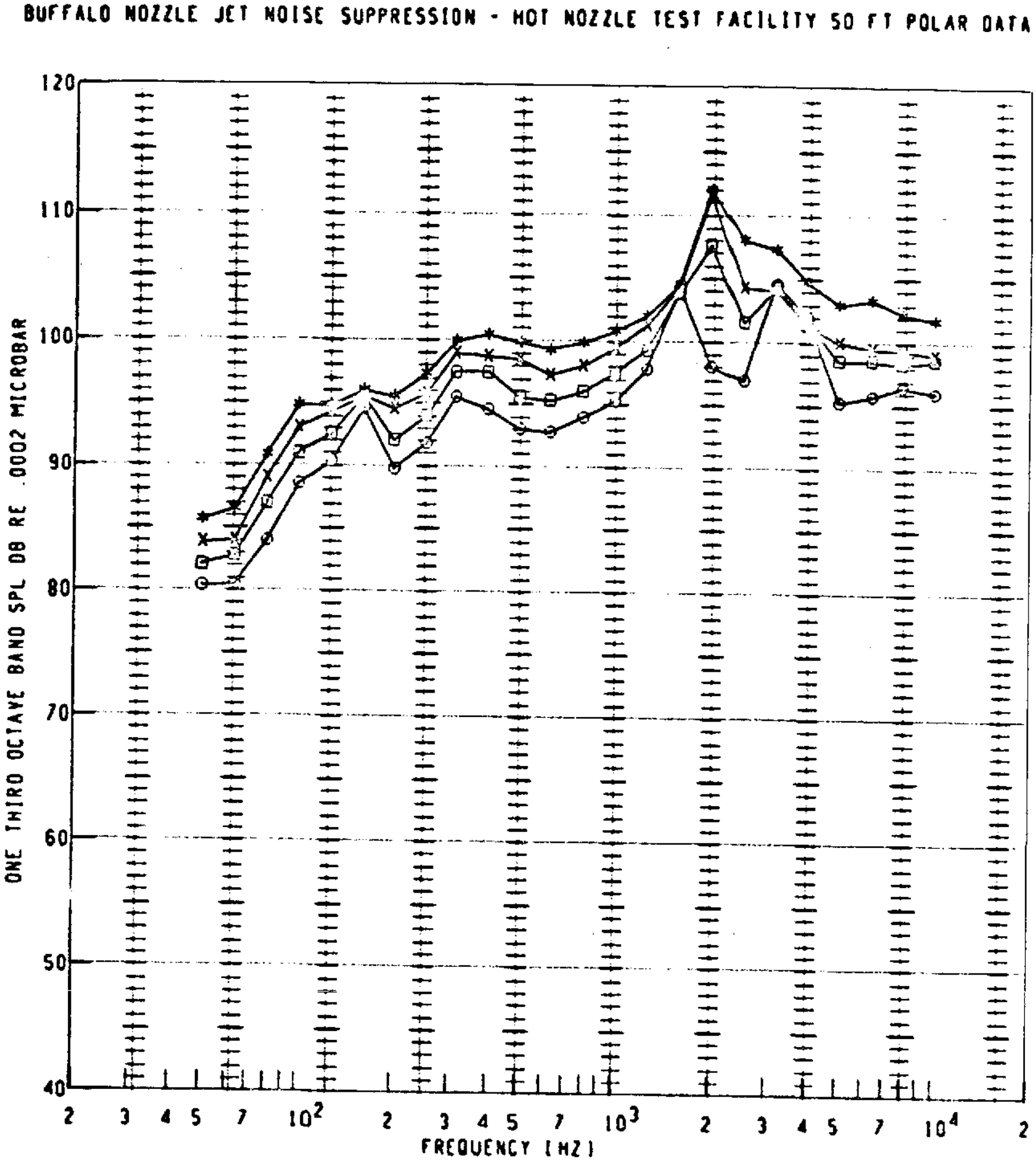
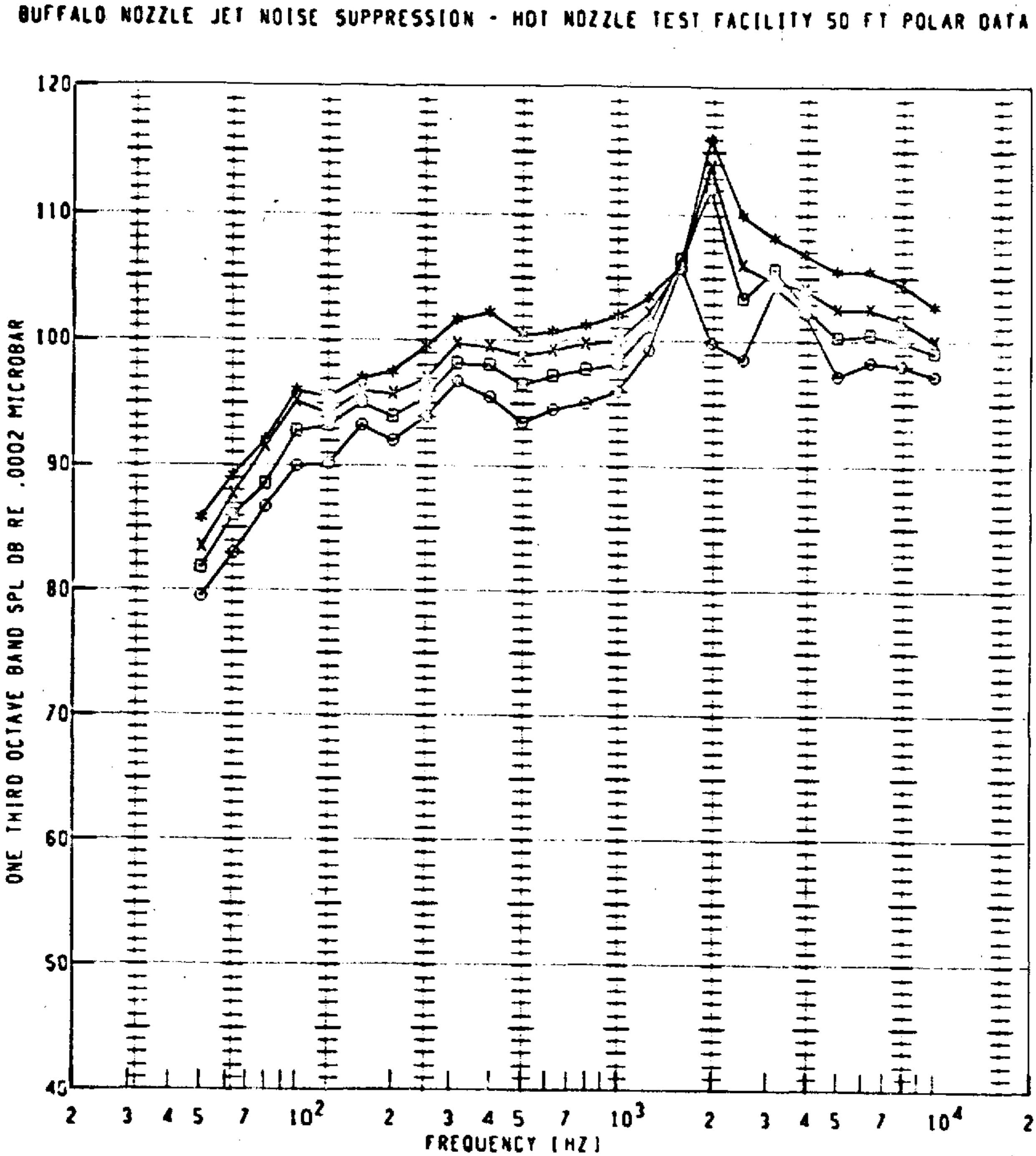


FIGURE 10.—BNS-1 NOZZLE WITH 7 CENTER LOBES FLOWING (*LOBES BLOCKED INTERNALLY)



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	90G	50FP	111.0	10	750 F
⊡	1	-0	1.400	90G	50FP	113.3	10	800 F
x	1	-0	1.500	90G	50FP	115.8	10	850 F
*	1	-0	1.600	90G	50FP	117.3	0	900 F

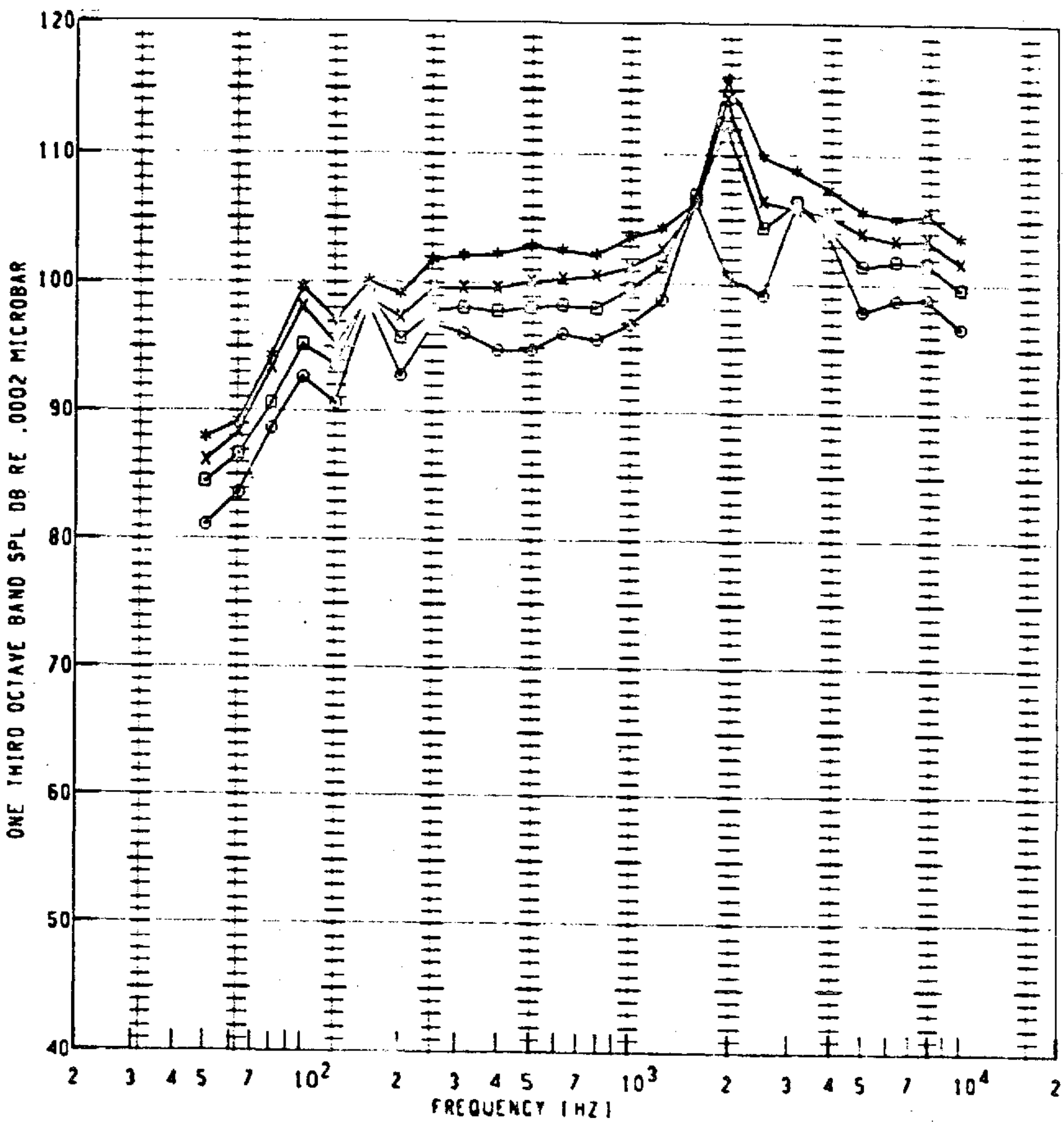
FIGURE 11.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	100G	50FP	112.5	10	750 F
⊡	1	-0	1.400	100G	50FP	116.2	10	800 F
x	1	-0	1.500	100G	50FP	117.5	10	850 F
*	1	-0	1.600	100G	50FP	120.0	0	900 F

FIGURE 12.—BUFFALO NOZZLE JET NOISE SUPPRESSION

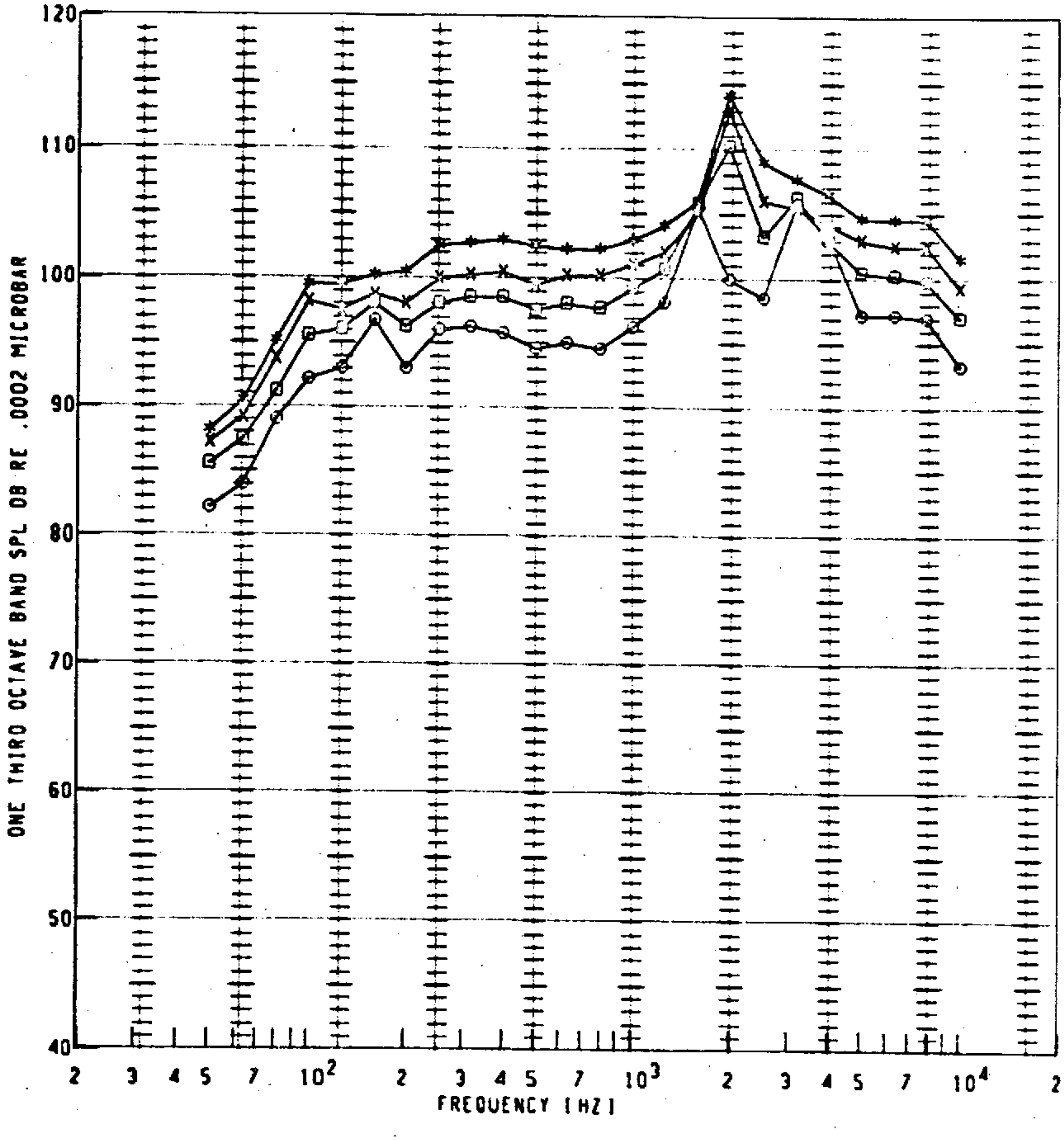
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	110G	50FP	113.6	10	750 F
⊡	1	-0	1.400	110G	50FP	116.3	10	800 F
x	1	-0	1.500	110G	50FP	118.1	10	850 F
*	1	-0	1.600	110G	50FP	119.8	0	900 F

FIGURE 13.—BUFFALO NOZZLE JET NOISE SUPPRESSION

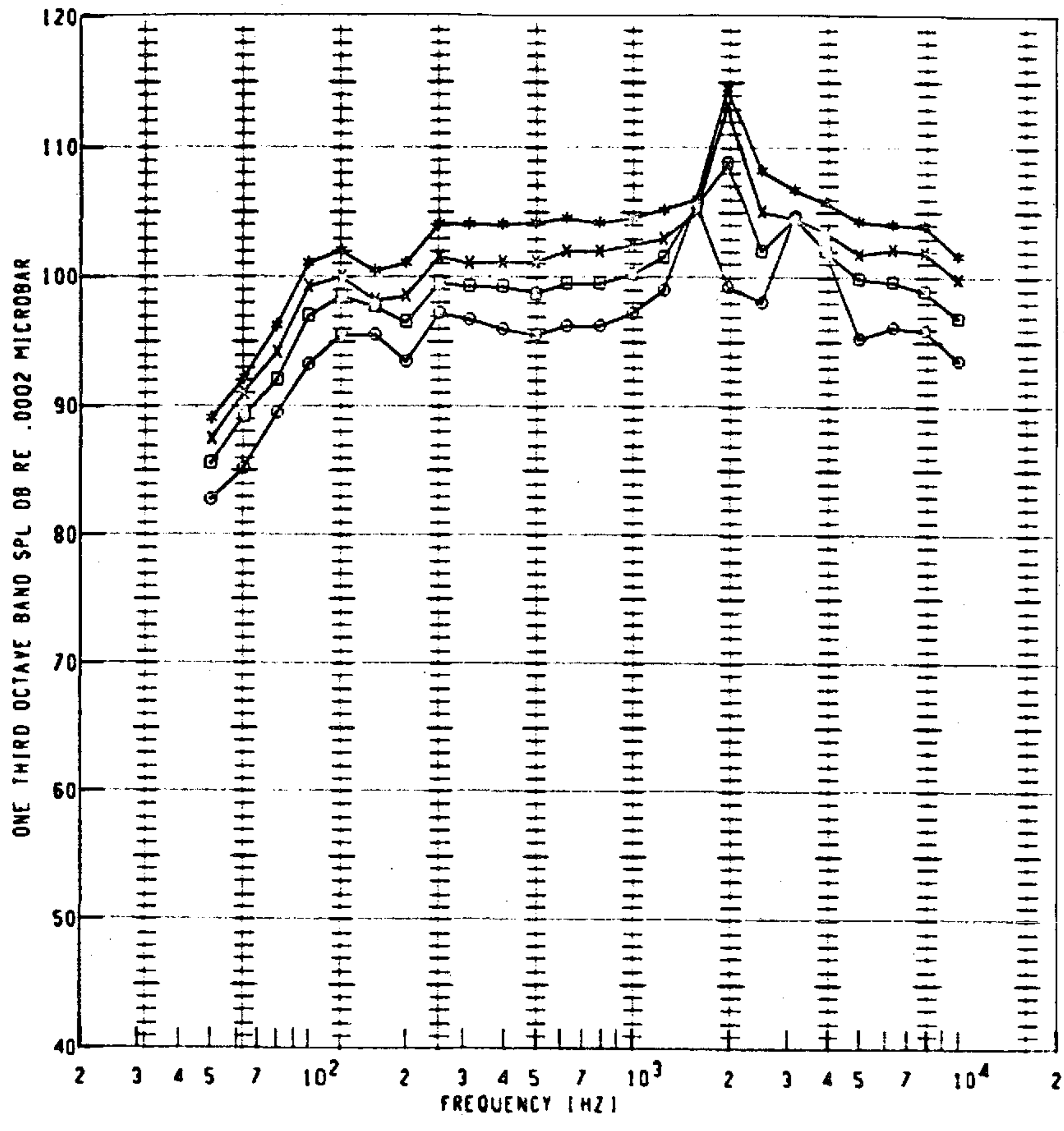
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	115G	50FP	112.5	10	750 F
⊡	1	-0	1.400	115G	50FP	115.2	10	800 F
X	1	-0	1.500	115G	50FP	117.2	10	850 F
*	1	-0	1.600	115G	50FP	119.0	0	900 F

FIGURE 14.—BUFFALO NOZZLE JET NOISE SUPPRESSION

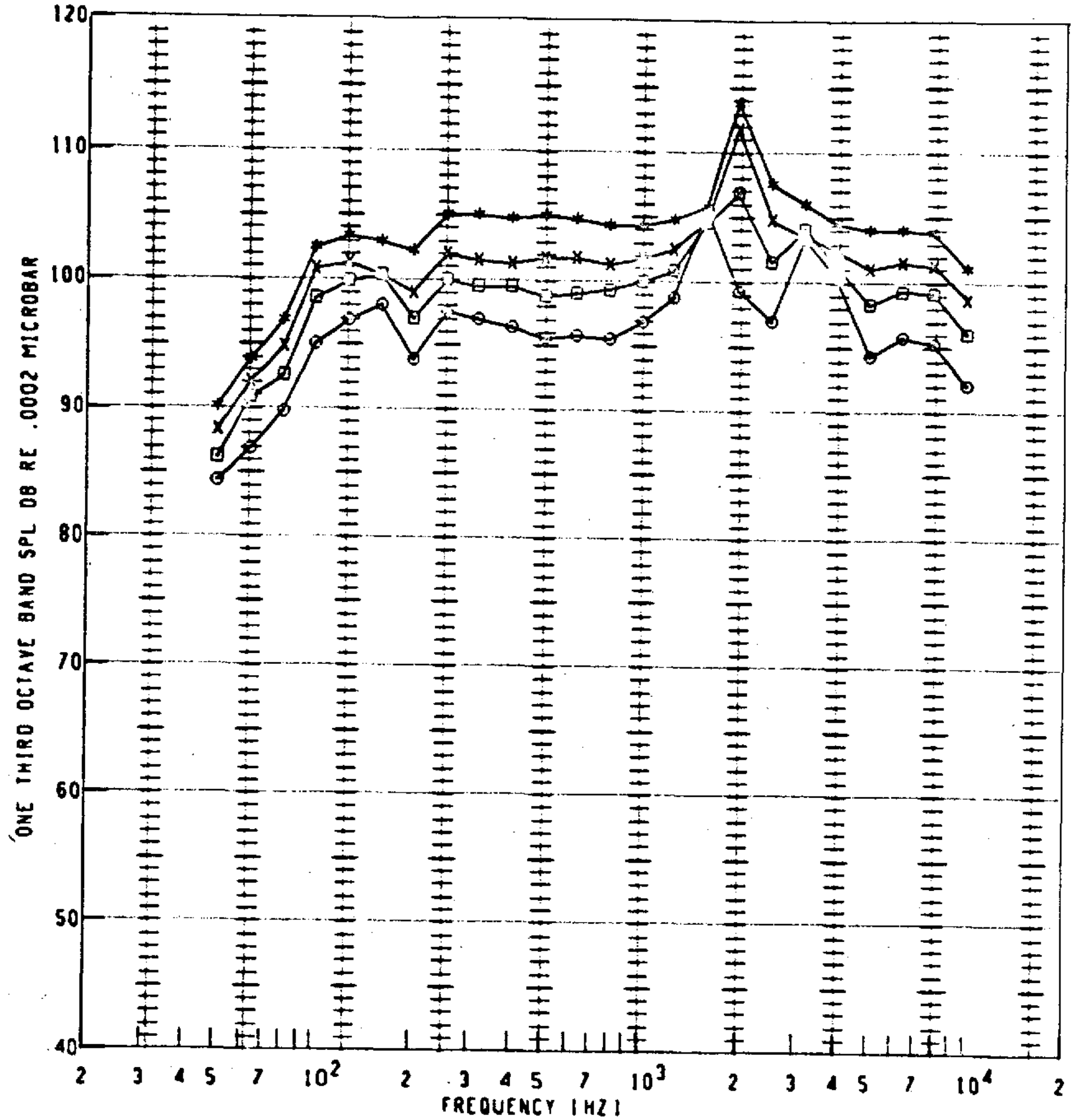
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	120G	50FP	112.2	10	750 F
⊡	1	-0	1.400	120G	50FP	115.0	10	800 F
x	1	-0	1.500	120G	50FP	117.2	10	850 F
*	1	-0	1.600	120G	50FP	119.5	0	900 F

FIGURE 15.—BUFFALO NOZZLE JET NOISE SUPPRESSION

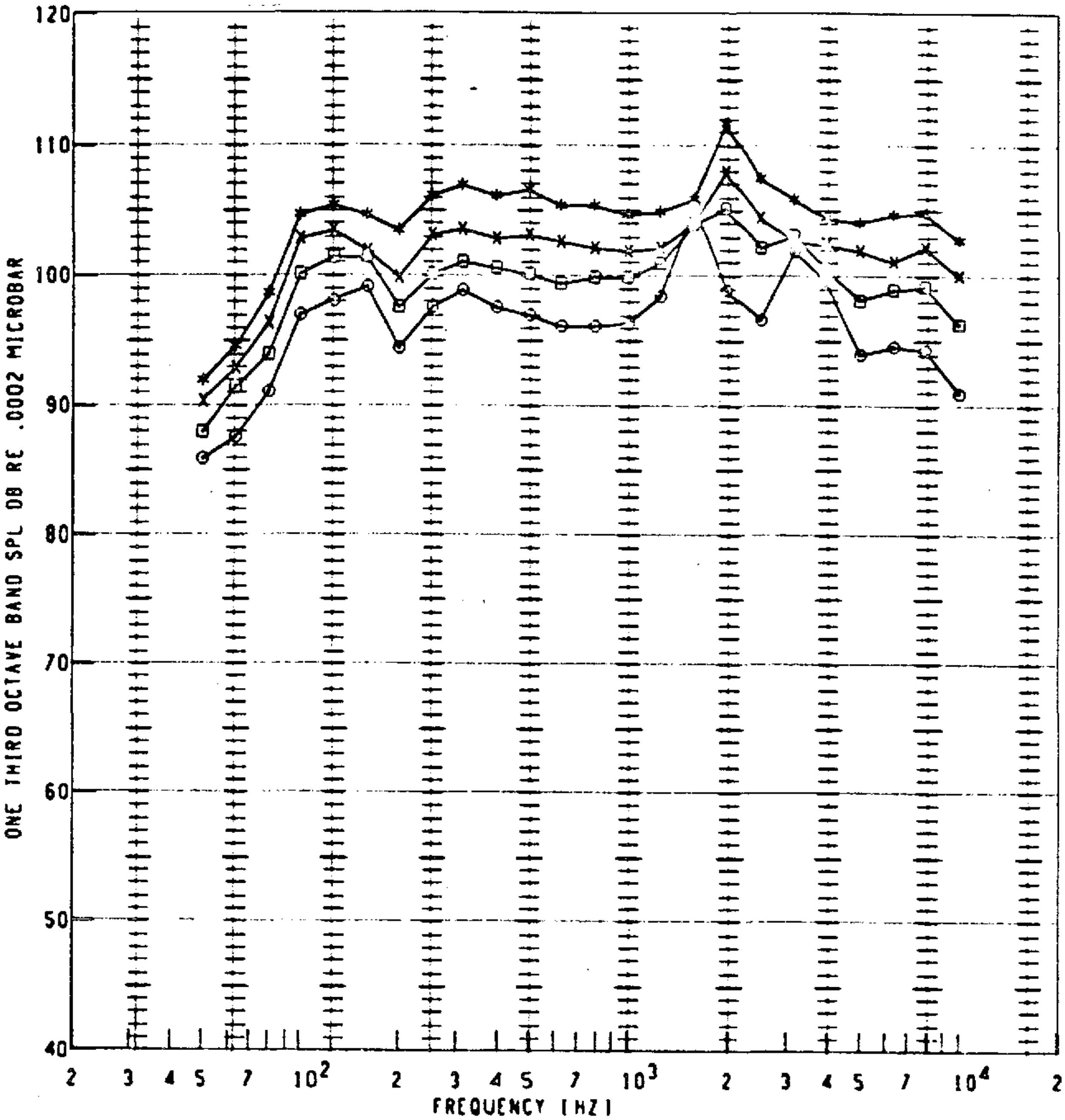
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	125G	50FP	111.8	10	750 F
⊡	1	-0	1.400	125G	50FP	114.3	10	800 F
X	1	-0	1.500	125G	50FP	116.5	10	850 F
*	1	-0	1.600	125G	50FP	118.8	0	900 F

FIGURE 16.—BUFFALO NOZZLE JET NOISE SUPPRESSION

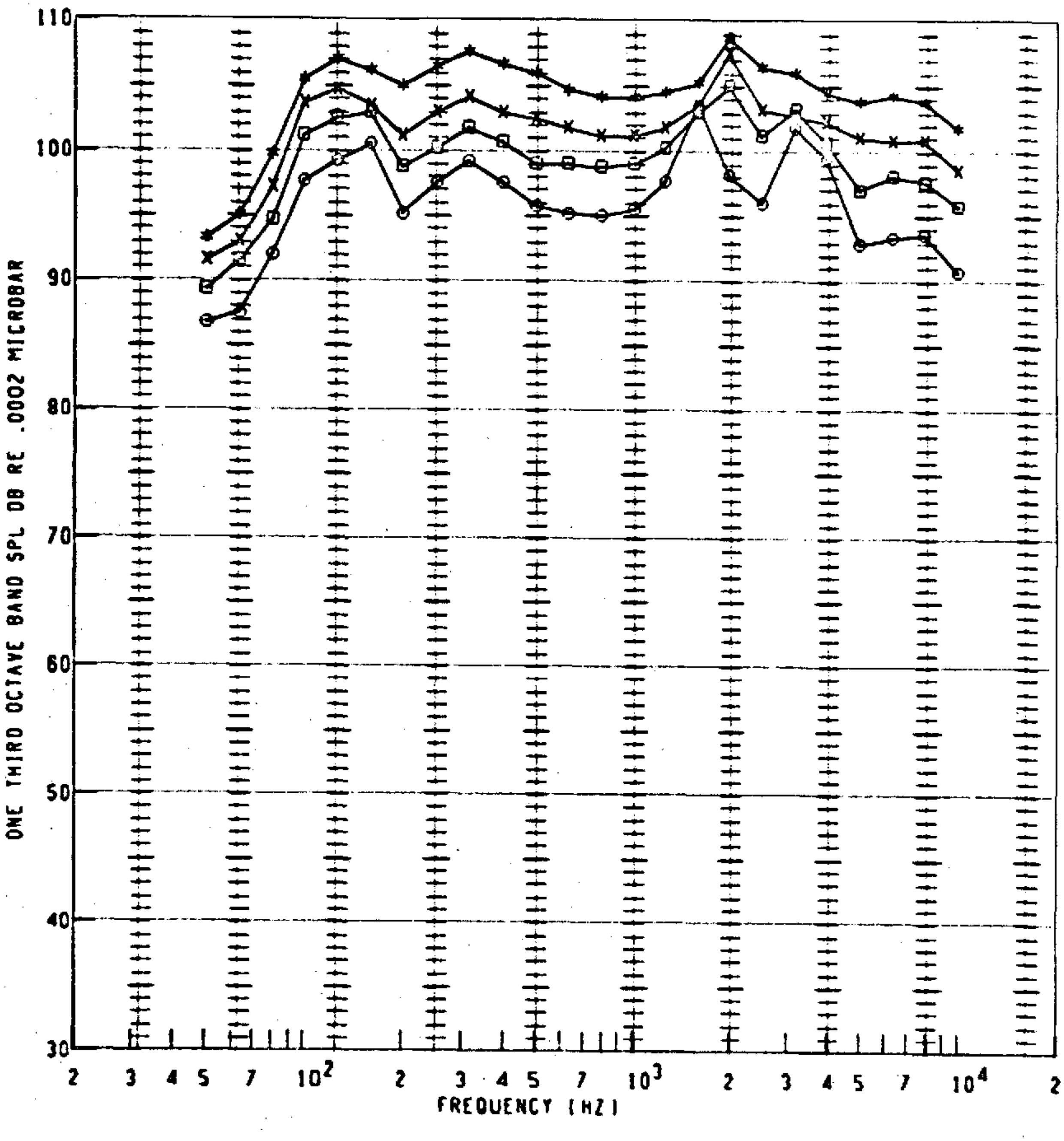
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	130G	50FP	111.6	10	750 F
⊡	1	-0	1.400	130G	50FP	113.9	10	800 F
X	1	-0	1.500	130G	50FP	116.6	10	850 F
*	1	-0	1.600	130G	50FP	119.4	0	900 F

FIGURE 17.—BUFFALO NOZZLE JET NOISE SUPPRESSION

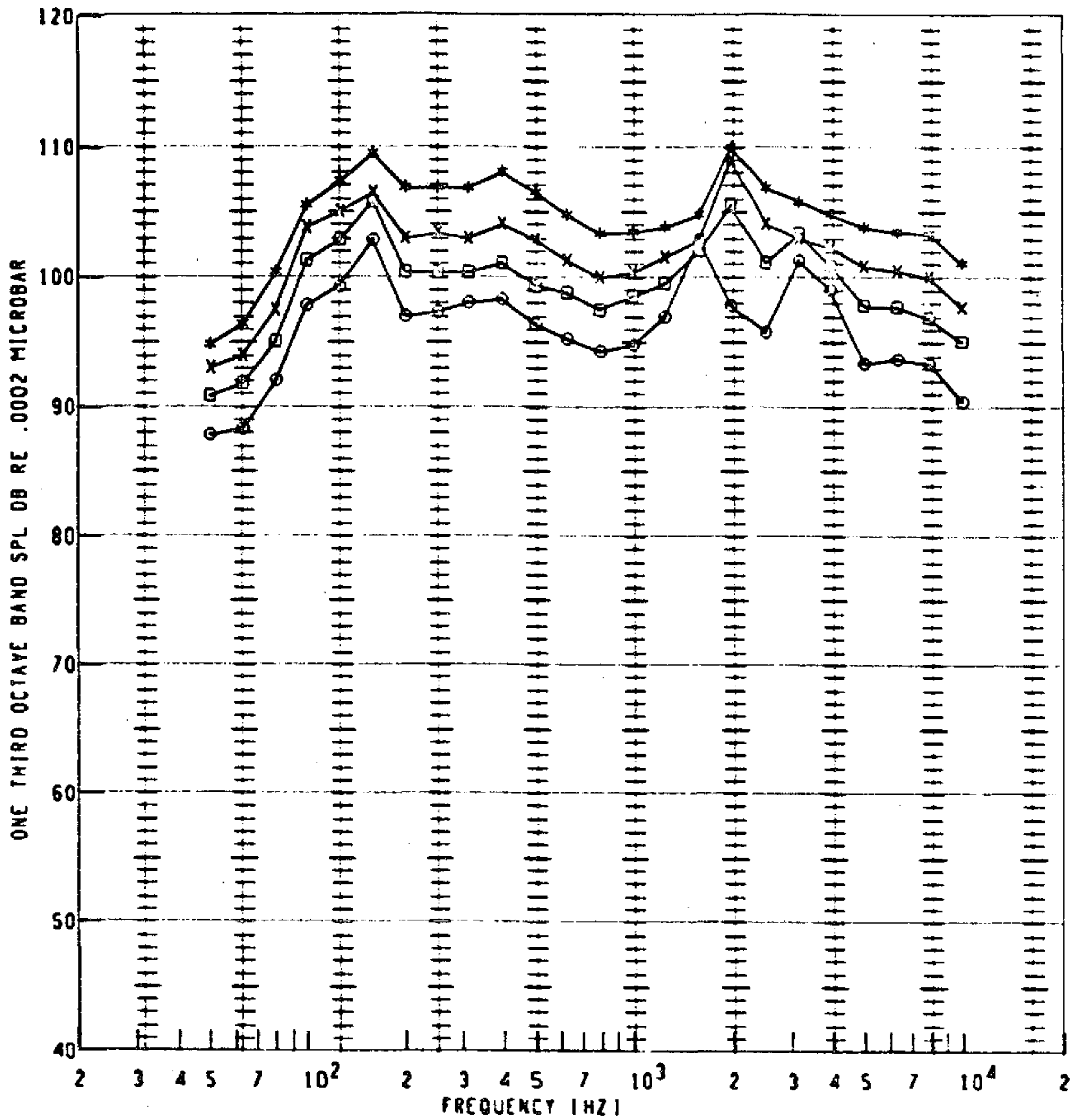
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	135G	50FP	111.2	10	750 F
⊡	1	-0	1.400	135G	50FP	114.0	10	800 F
X	1	-0	1.500	135G	50FP	116.5	10	850 F
*	1	-0	1.600	135G	50FP	119.2	0	900 F

FIGURE 18.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	1	-0	1.300	140G	50FP	111.5	10	750 F
⊡	1	-0	1.400	140G	50FP	114.5	10	800 F
x	1	-0	1.500	140G	50FP	116.8	10	850 F
*	1	-0	1.600	140G	50FP	119.0	0	900 F

FIGURE 19.—BUFFALO NOZZLE JET NOISE SUPPRESSION

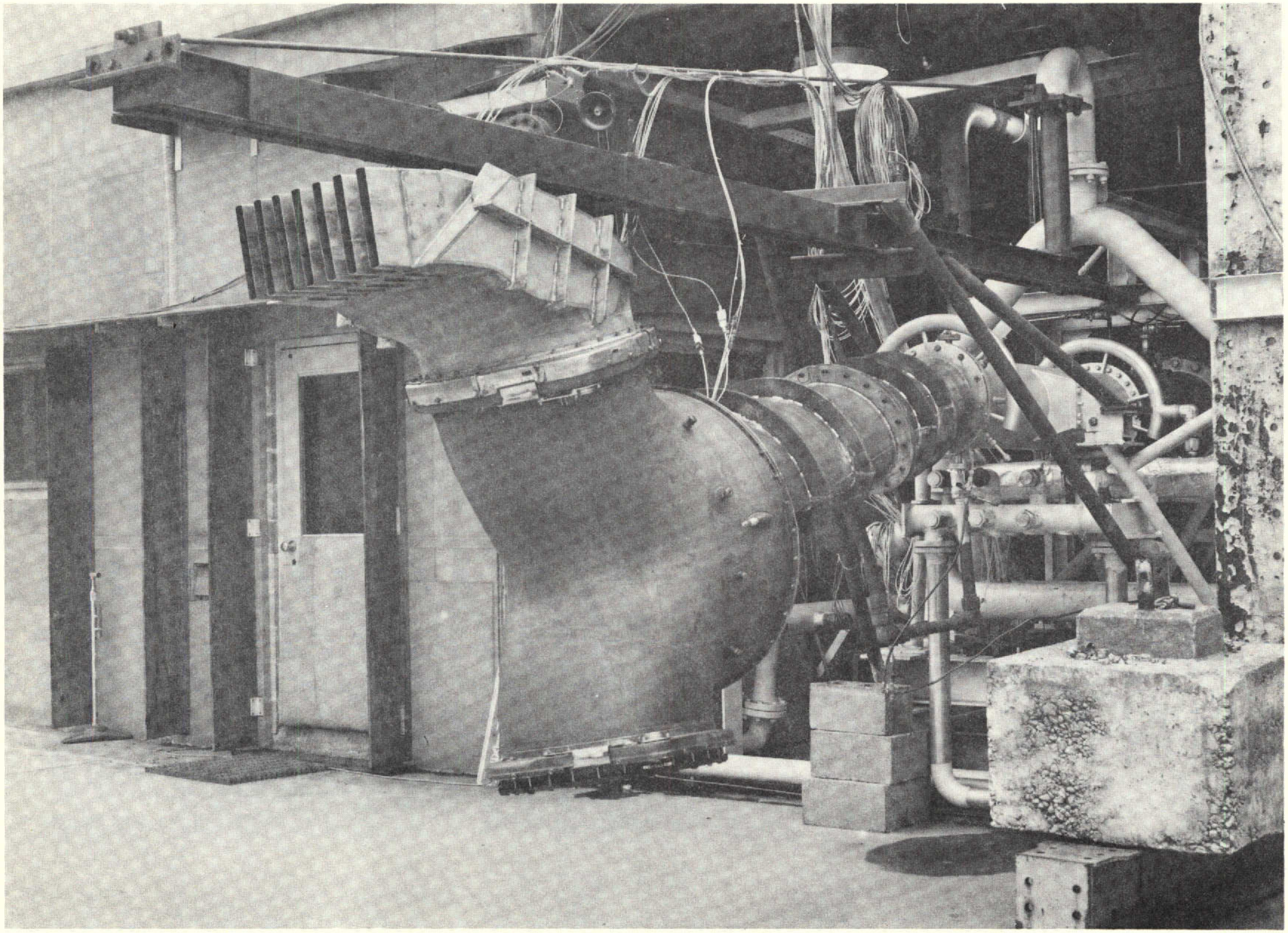


FIGURE 20.—BNS-3 NOZZLE WITH PLAIN CONVERGENT ENDS

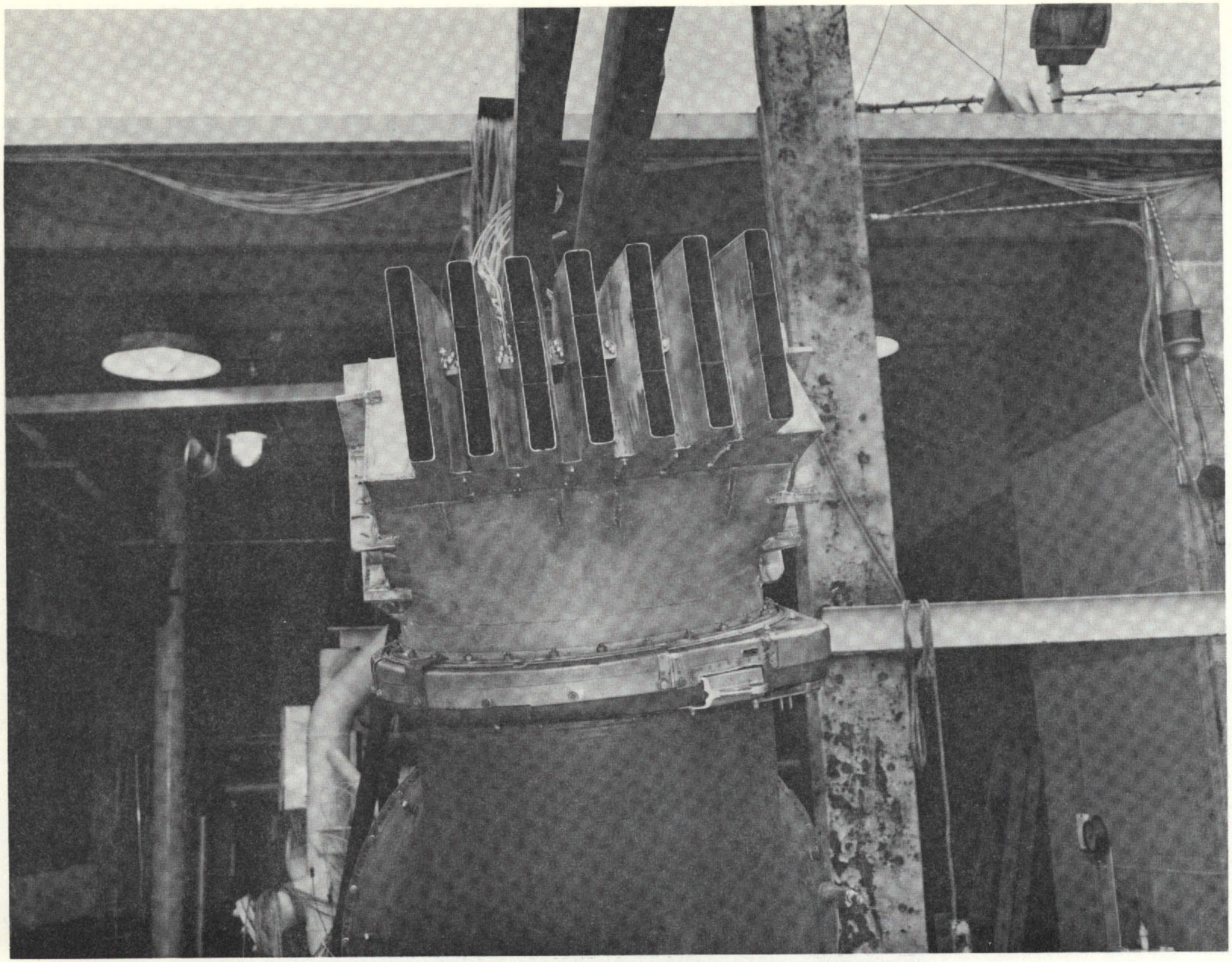


FIGURE 21.—BNS-3 WITH PLAIN CONVERGENT ENDS

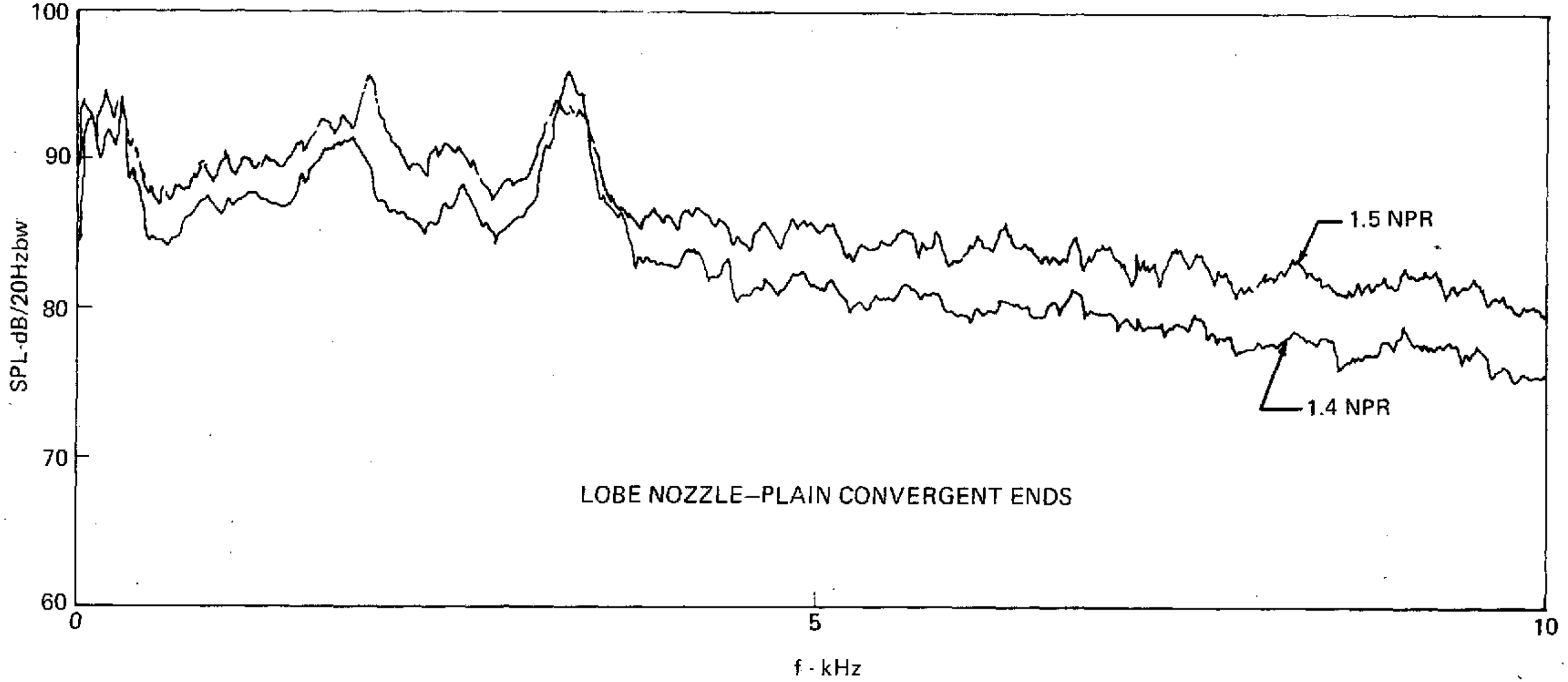
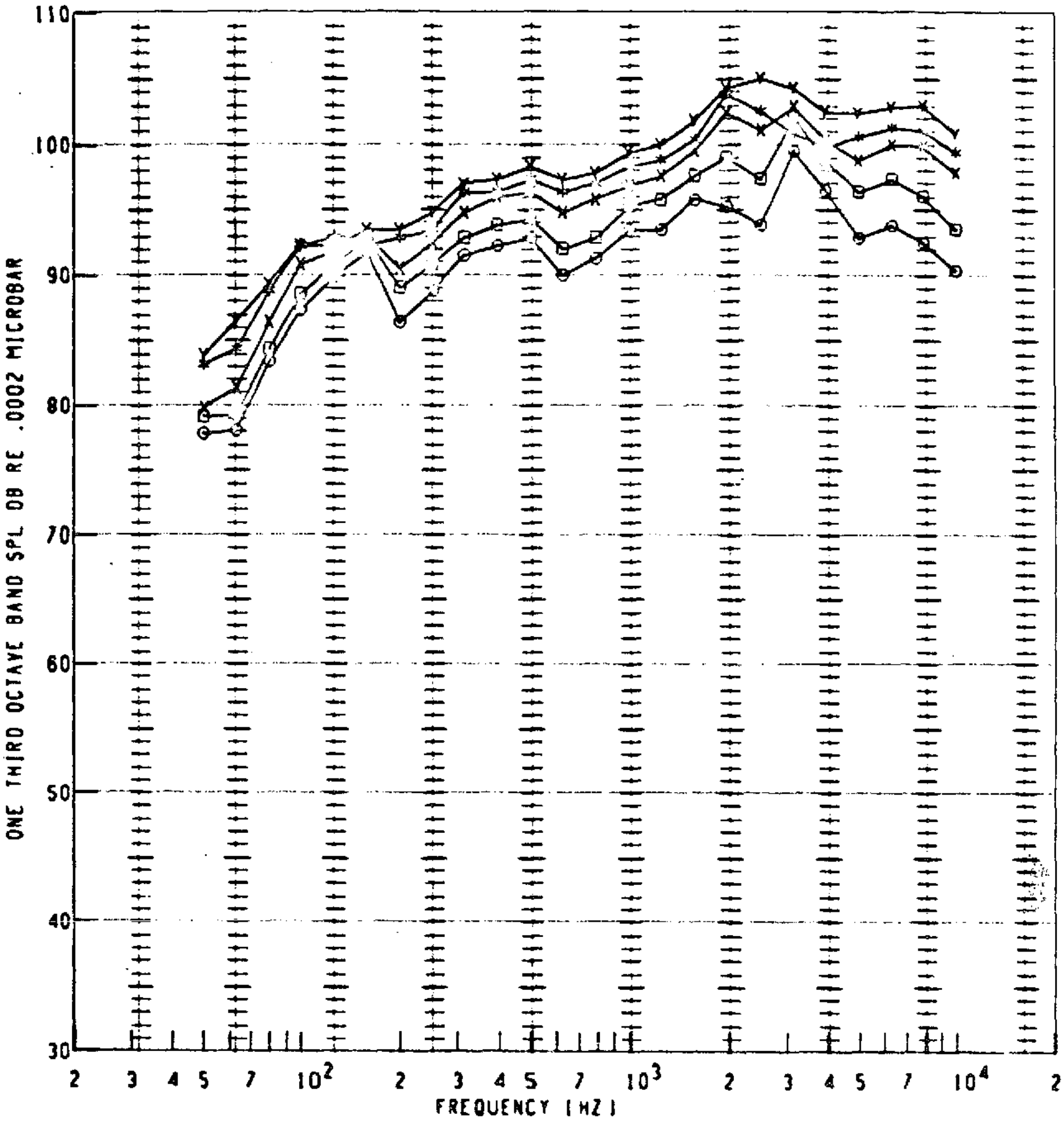


FIGURE 22.—NARROW-BAND ACOUSTICS OF RUN 3 AT 115° ANGLE

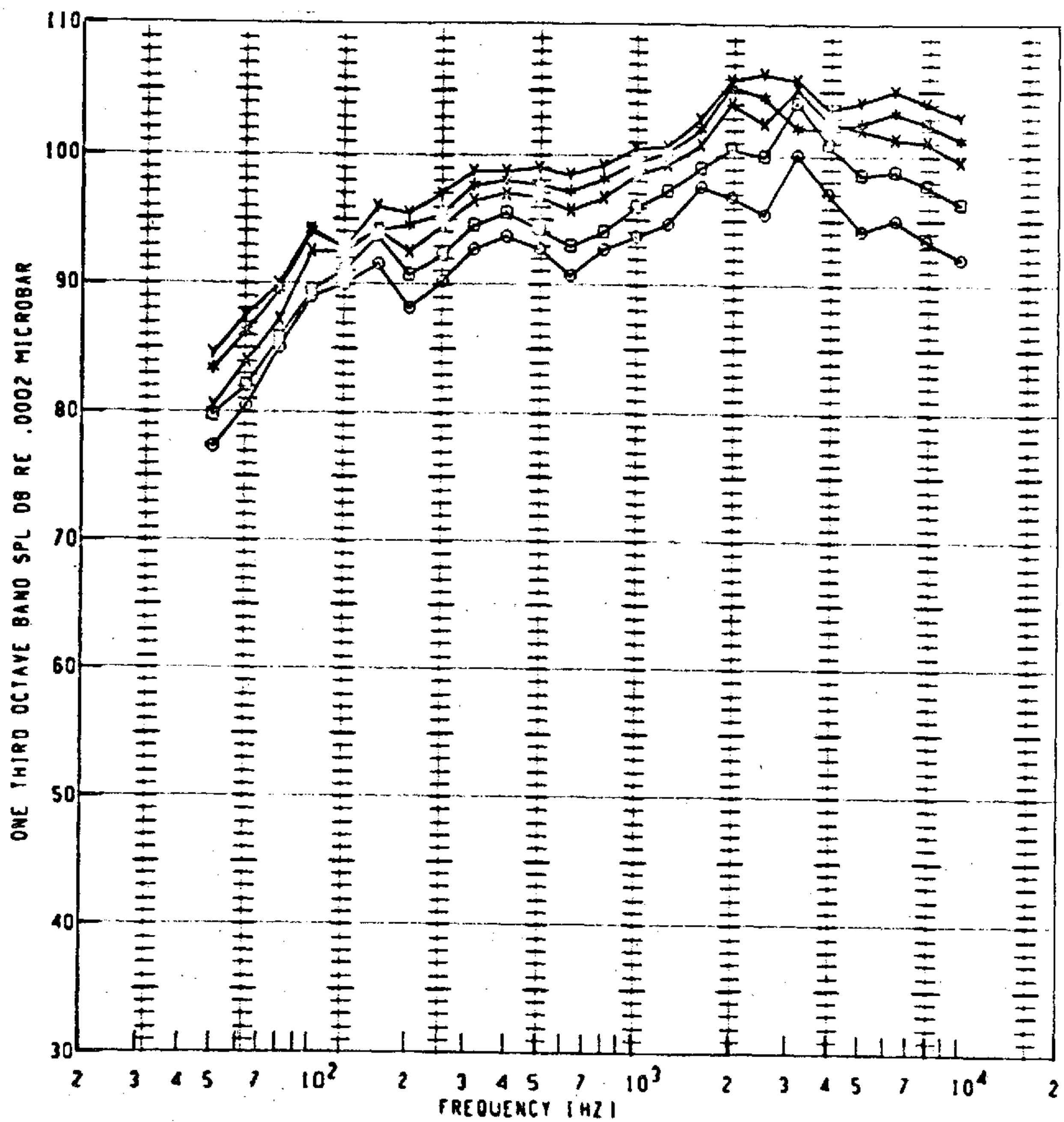
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	3	-0	1.300	90G	50FP	106.8	10	750 F
⊡	3	-0	1.400	90G	50FP	109.3	10	800 F
X	3	-0	1.500	90G	50FP	111.8	10	850 F
*	3	-0	1.600	90G	50FP	112.5	10	900 F
Y	3	-0	1.700	90G	50FP	114.3	10	950 F

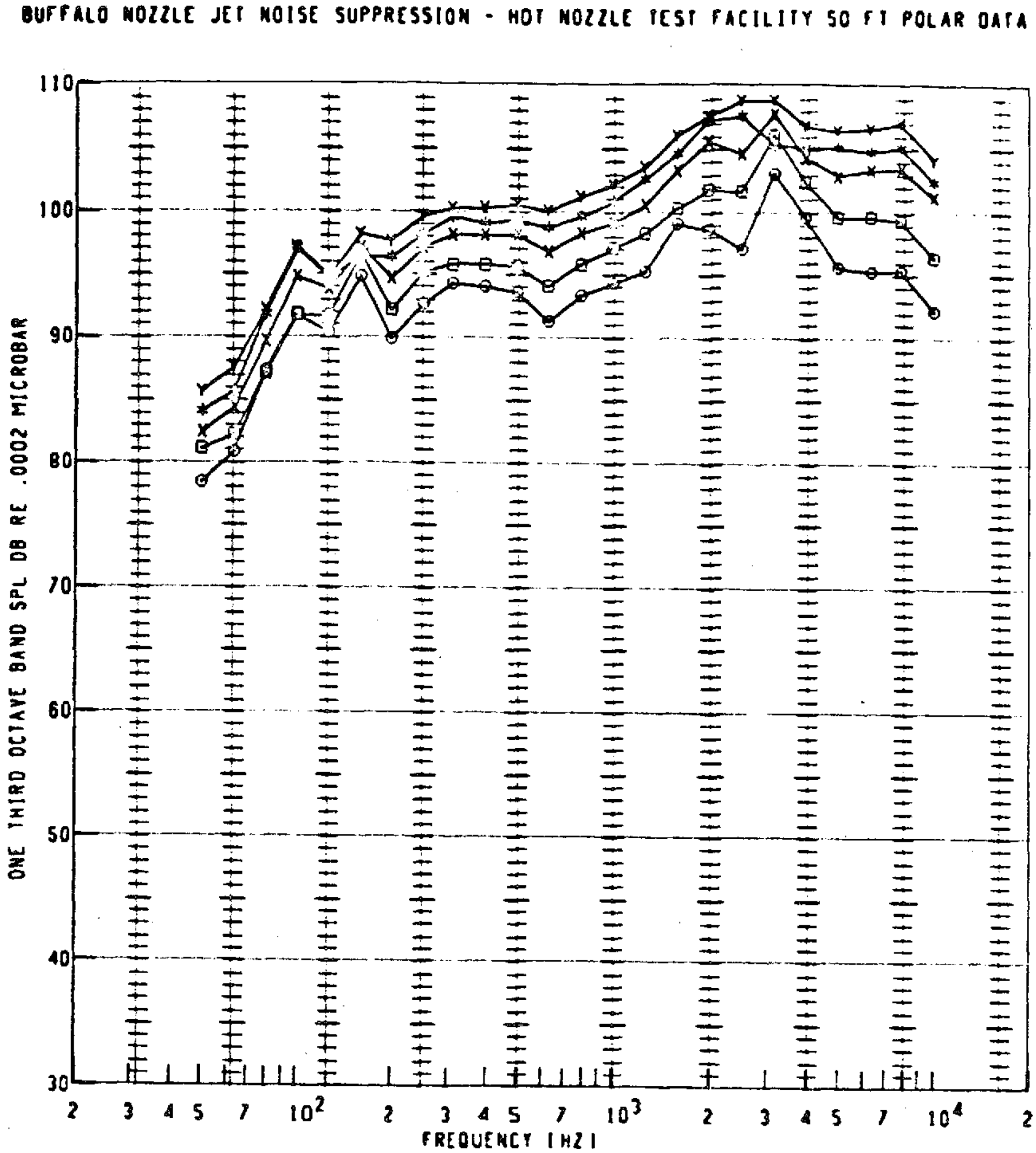
FIGURE 23.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	3	-0	1.300	100G	50FP	108.5	10	750 F
⊡	3	-0	1.400	100G	50FP	111.7	10	800 F
X	3	-0	1.500	100G	50FP	113.5	10	850 F
*	3	-0	1.600	100G	50FP	114.5	10	900 F
Y	3	-0	1.700	100G	50FP	116.2	10	950 F

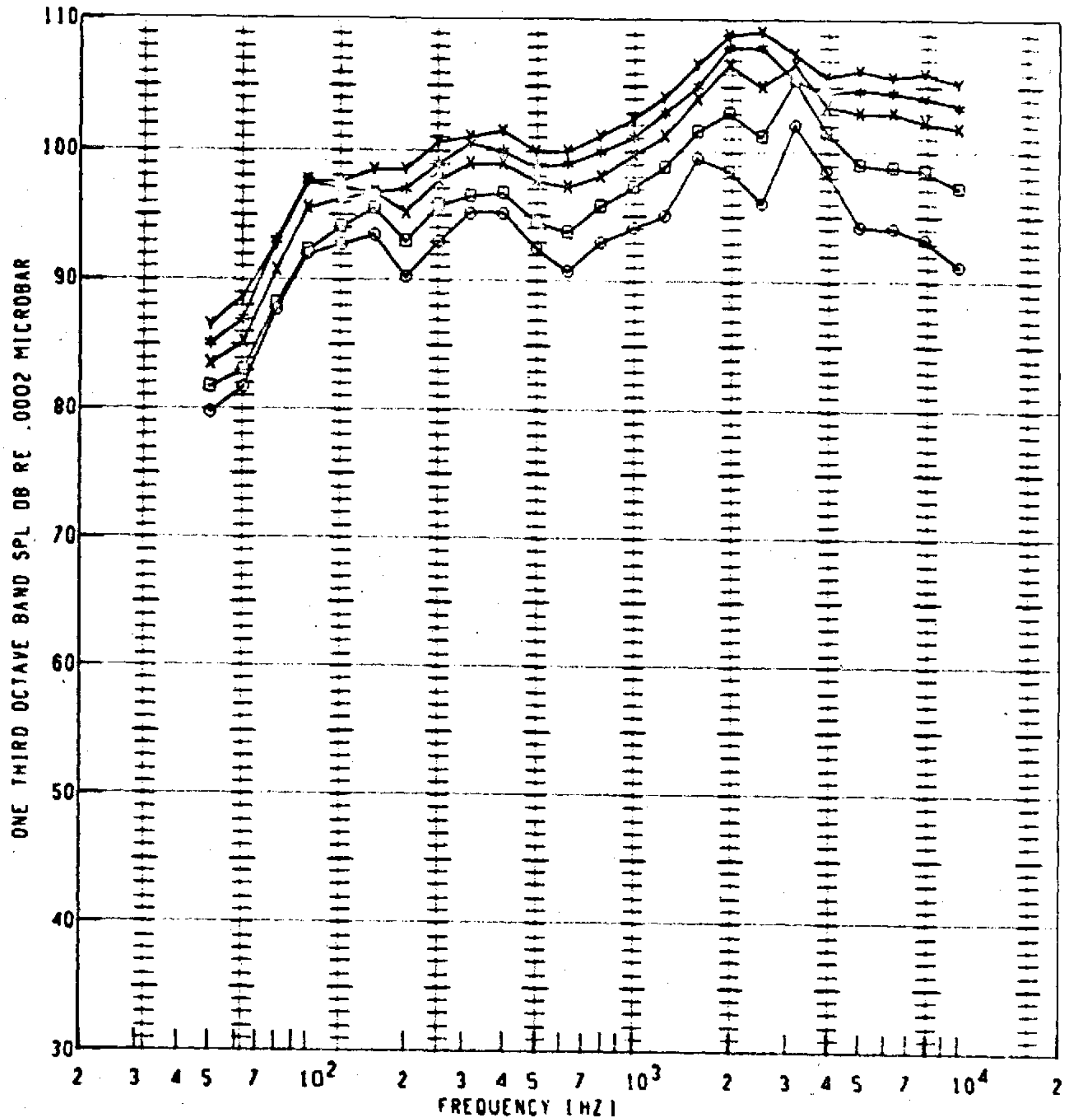
FIGURE 24.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	3	-0	1.300	110G	50FP	109.6	10	750 F
⊡	3	-0	1.400	110G	50FP	112.6	10	800 F
X	3	-0	1.500	110G	50FP	115.3	10	850 F
*	3	-0	1.600	110G	50FP	116.6	10	900 F
Y	3	-0	1.700	110G	50FP	117.8	0	950 F

FIGURE 25.—BUFFALO NOZZLE JET NOISE SUPPRESSION

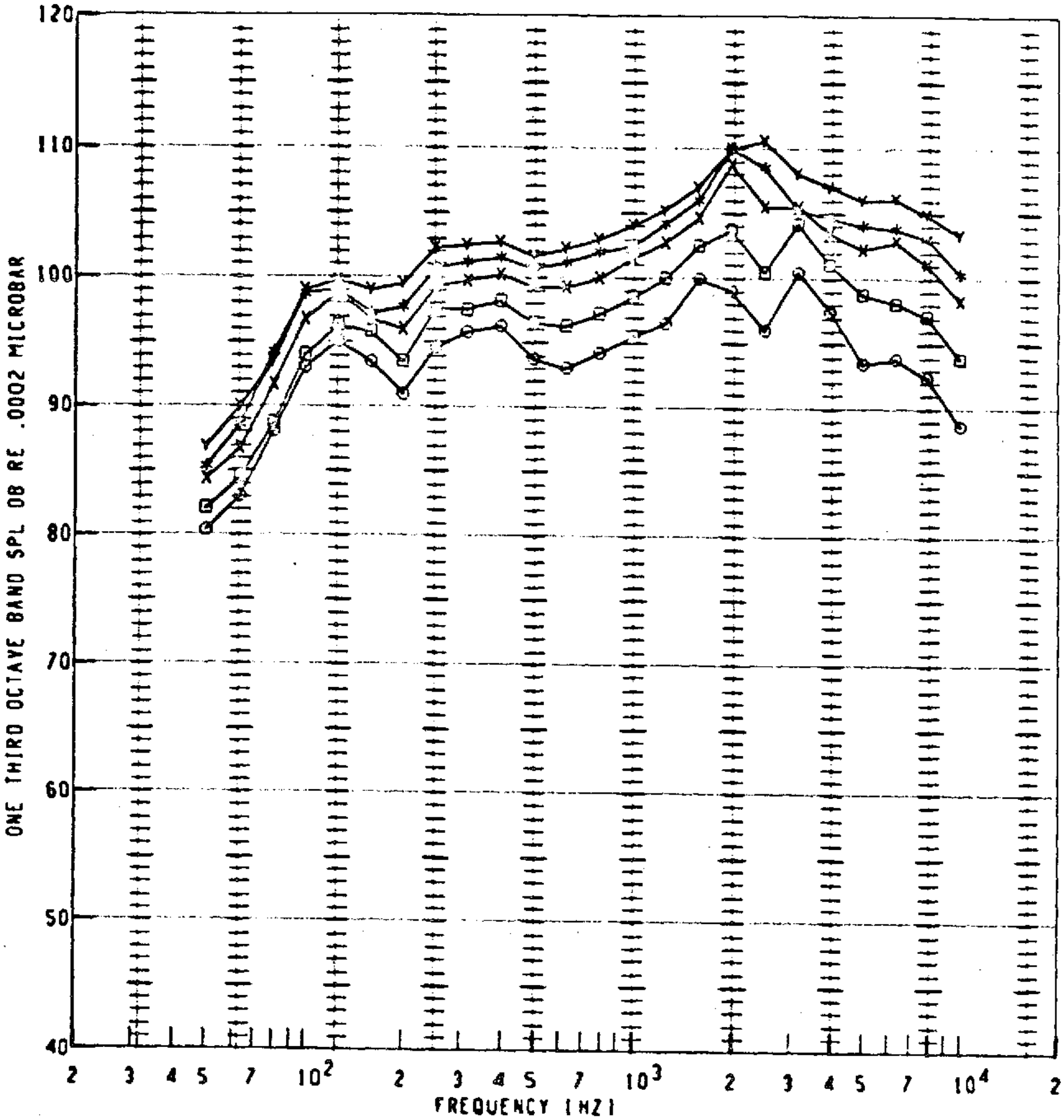
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	3	-0	1.300	115G	50FP	109.0	10	750 F
⊡	3	-0	1.400	115G	50FP	112.2	10	800 F
X	3	-0	1.500	115G	50FP	115.2	10	850 F
*	3	-0	1.600	115G	50FP	116.5	10	900 F
Y	3	-0	1.700	115G	50FP	118.0	0	950 F

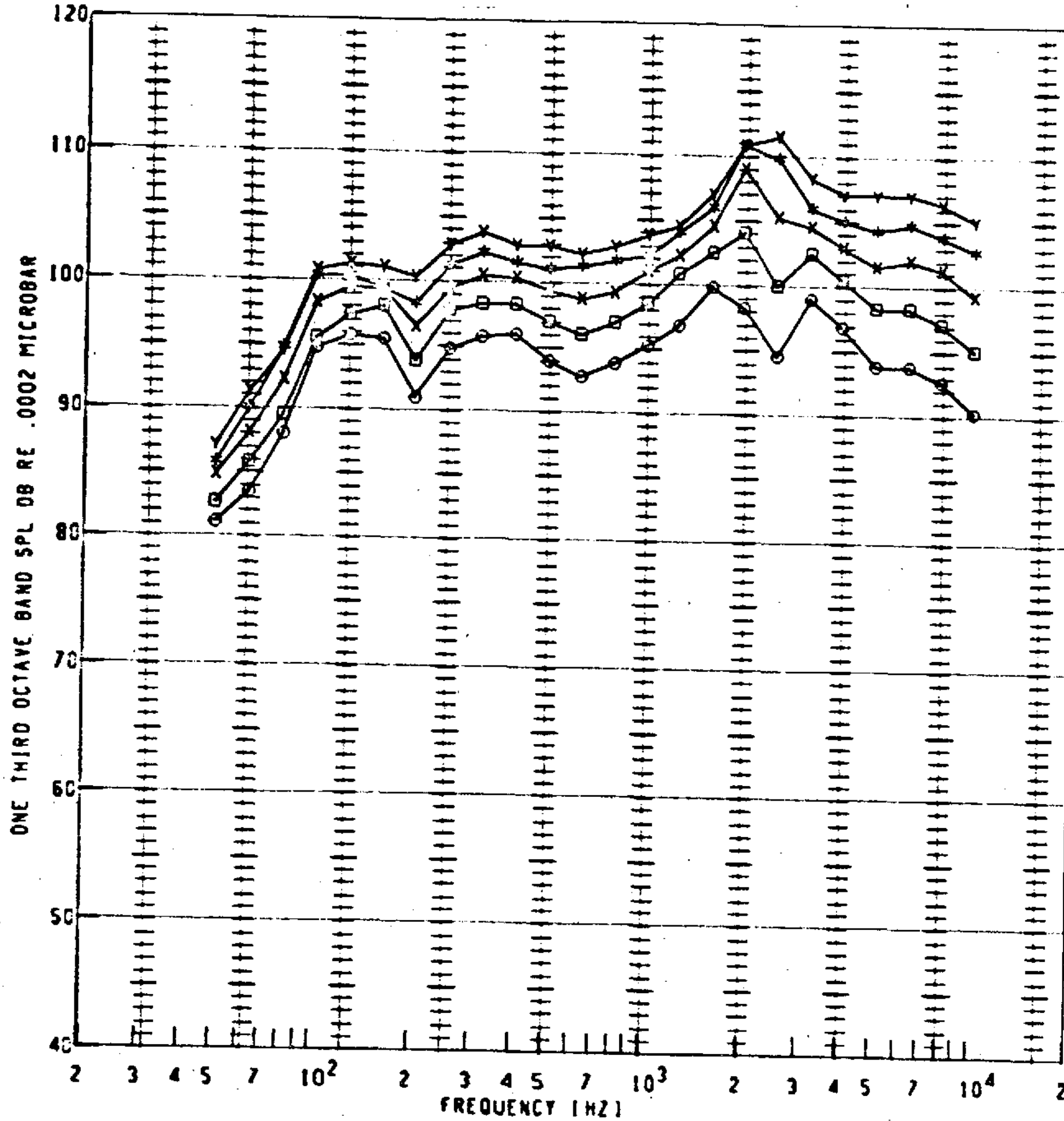
FIGURE 26.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	3	-0	1.300	120G	50FP	109.2	10	750 F
⊡	3	-0	1.400	120G	50FP	112.5	10	800 F
X	3	-0	1.500	120G	50FP	115.5	10	850 F
*	3	-0	1.600	120G	50FP	117.5	10	900 F
Y	3	-0	1.700	120G	50FP	118.7	0	950 F

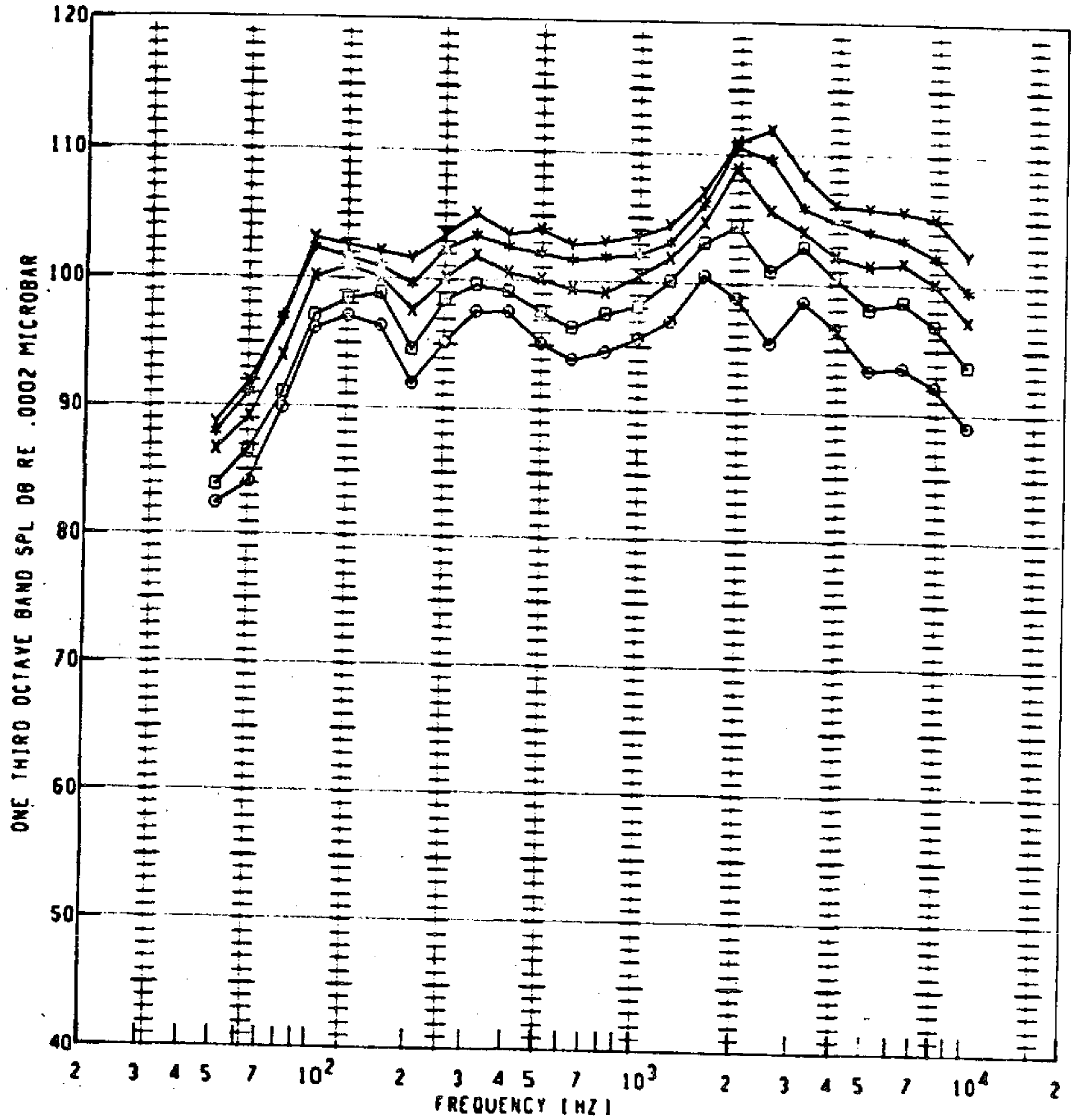
FIGURE 27.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	3	-0	1.300	125G	50FP	109.0	10	750 F
⊟	3	-0	1.400	125G	50FP	112.3	10	800 F
X	3	-0	1.500	125G	50FP	115.3	10	850 F
*	3	-0	1.600	125G	50FP	118.0	10	900 F
Y	3	-0	1.700	125G	50FP	119.3	0	950 F

FIGURE 28.—BUFFALO NOZZLE JET NOISE SUPPRESSION

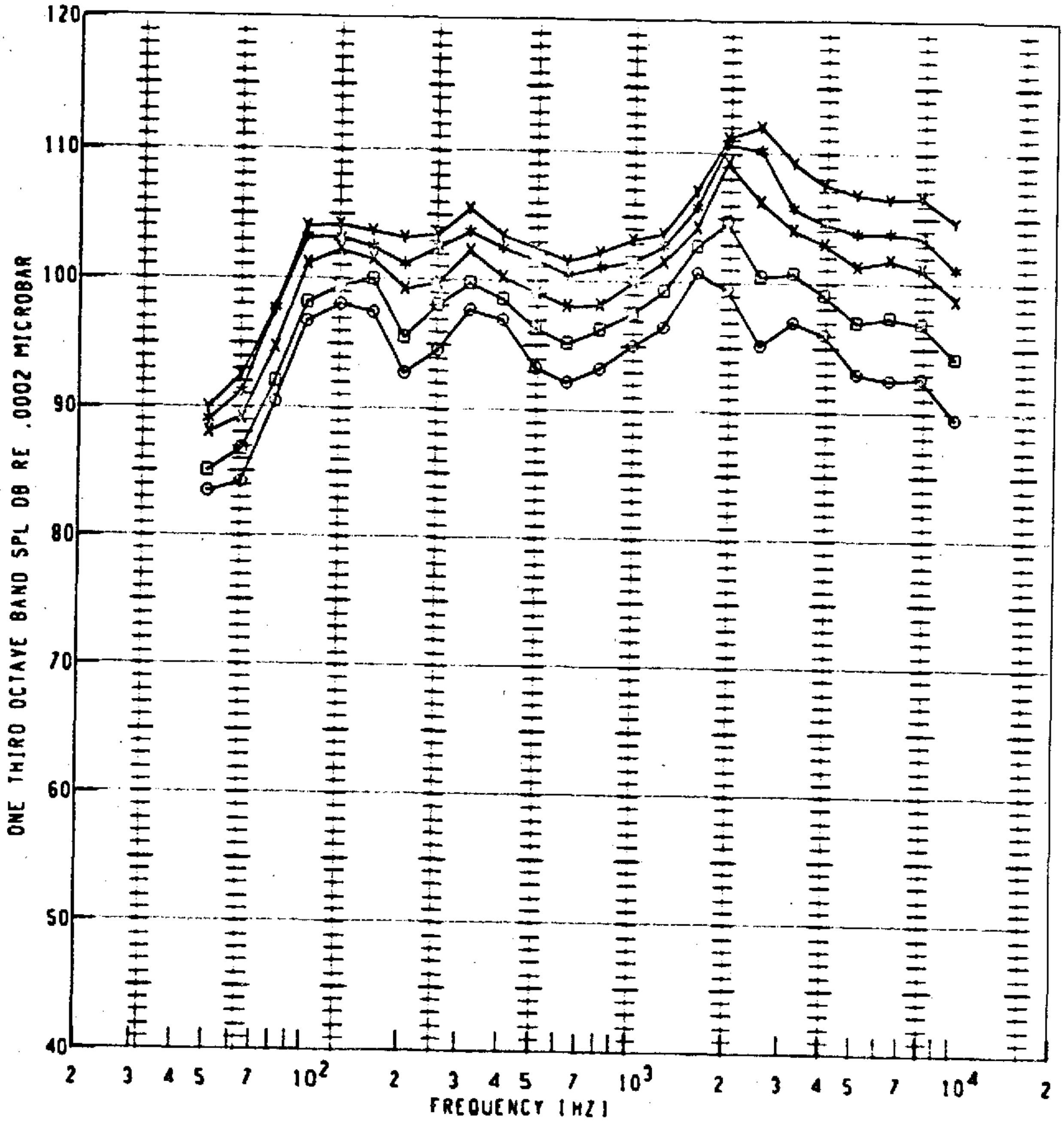
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	3	-0	1.300	130G	50FP	109.6	10	750 F
⊡	3	-0	1.400	130G	50FP	112.6	10	800 F
X	3	-0	1.500	130G	50FP	115.9	10	850 F
*	3	-0	1.600	130G	50FP	117.9	10	900 F
Y	3	-0	1.700	130G	50FP	119.4	0	950 F

FIGURE 29.—BUFFALO NOZZLE JET NOISE SUPPRESSION

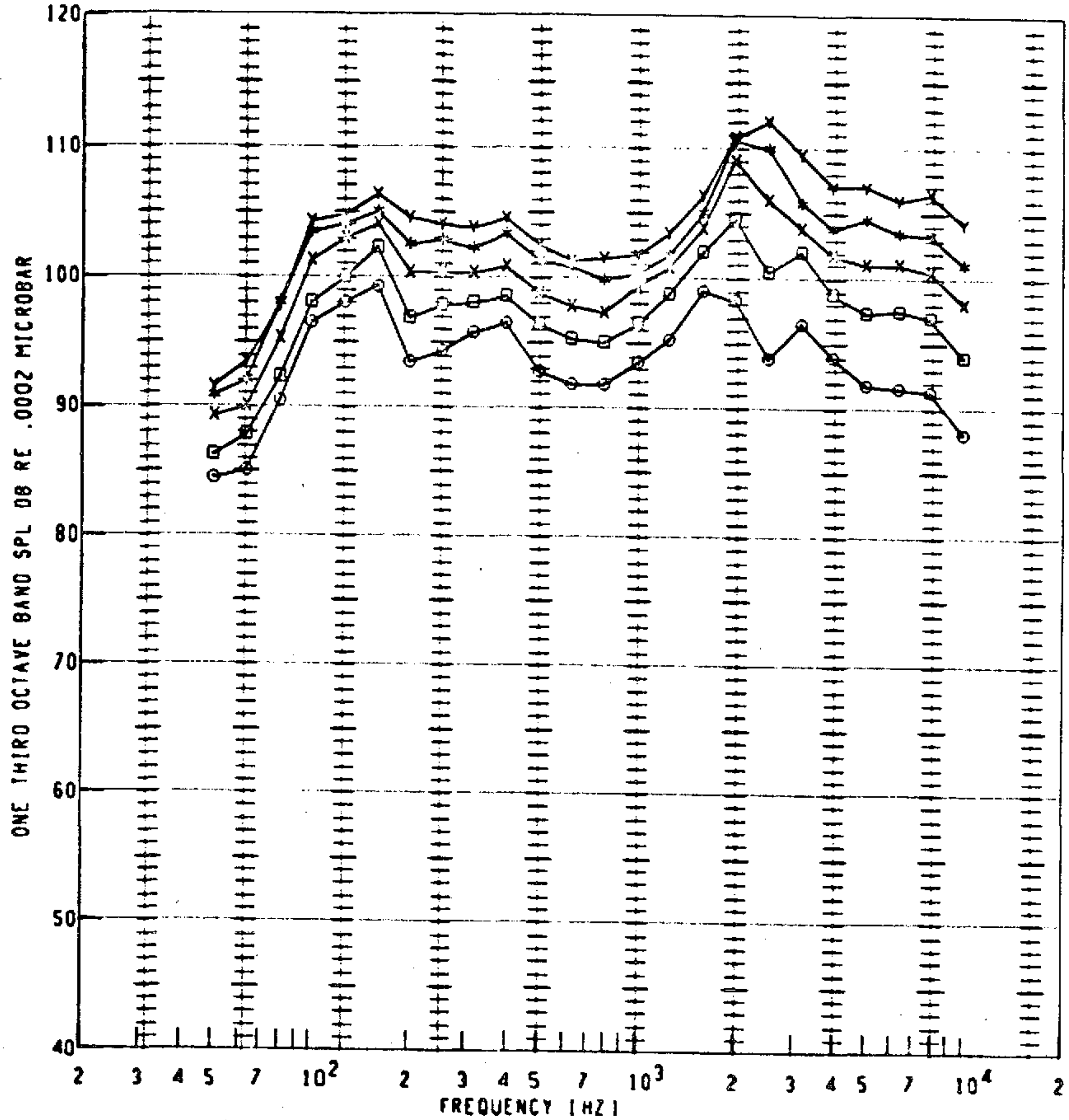
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	3	-0	1.300	135G	50FP	109.5	10	750 F
⊡	3	-0	1.400	135G	50FP	112.5	10	800 F
X	3	-0	1.500	135G	50FP	116.0	10	850 F
*	3	-0	1.600	135G	50FP	118.5	10	900 F
Y	3	-0	1.700	135G	50FP	120.2	0	950 F

FIGURE 30.—BUFFALO NOZZZE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	3	-0	1.300	140G	50FP	108.8	10	750 F
⊡	3	-0	1.400	140G	50FP	112.5	10	800 F
X	3	-0	1.500	140G	50FP	116.3	10	850 F
*	3	-0	1.600	140G	50FP	118.0	0	900 F
Y	3	-0	1.700	140G	50FP	120.0	0	950 F

FIGURE 31.—BUFFALO NOZZLE JET NOISE SUPPRESSION

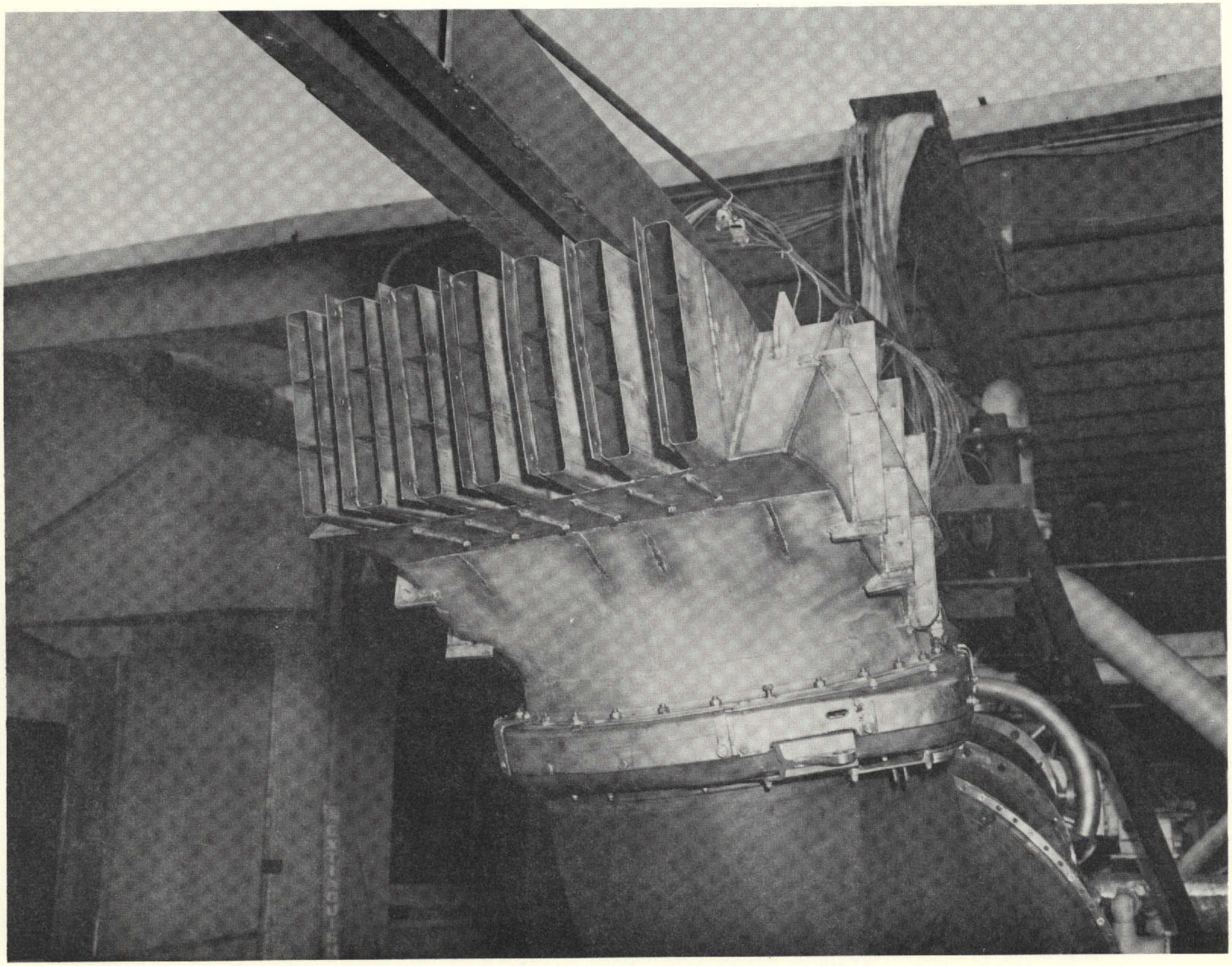
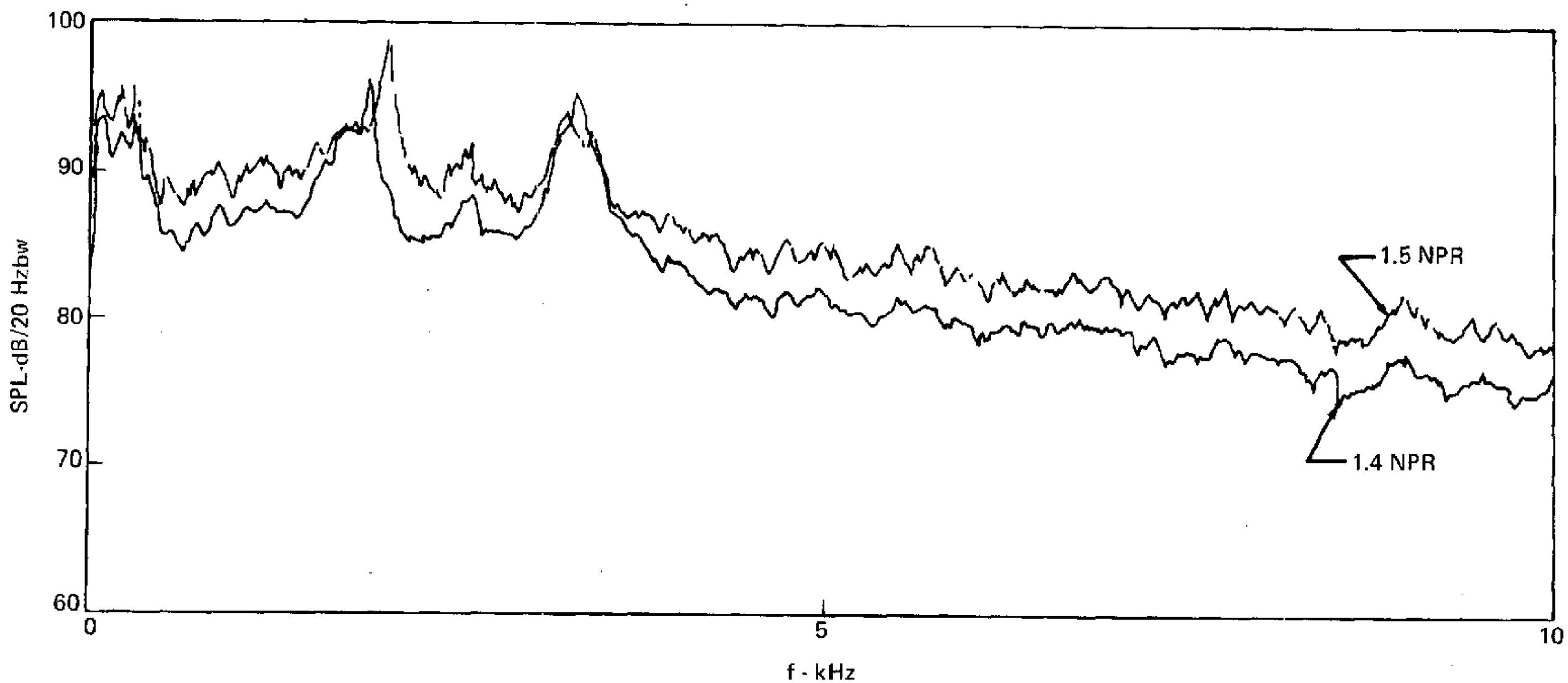


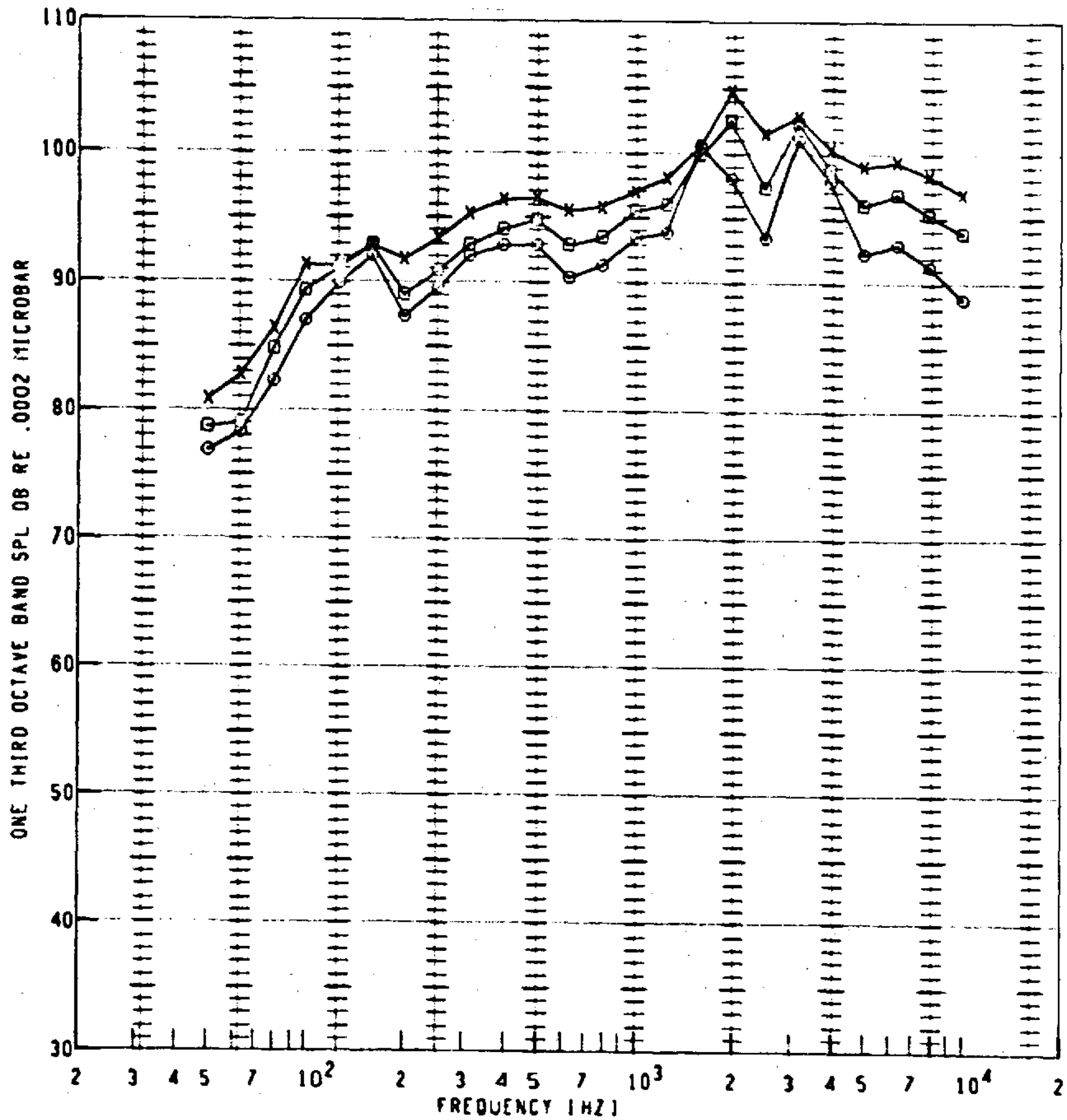
FIGURE 32.—1-IN. FENCES ATTACHED TO LOBE WALLS



LOBE NOZZLE PLAIN CONVERGENT ENDS
WITH (2.54 CM) 1-IN. FENCES

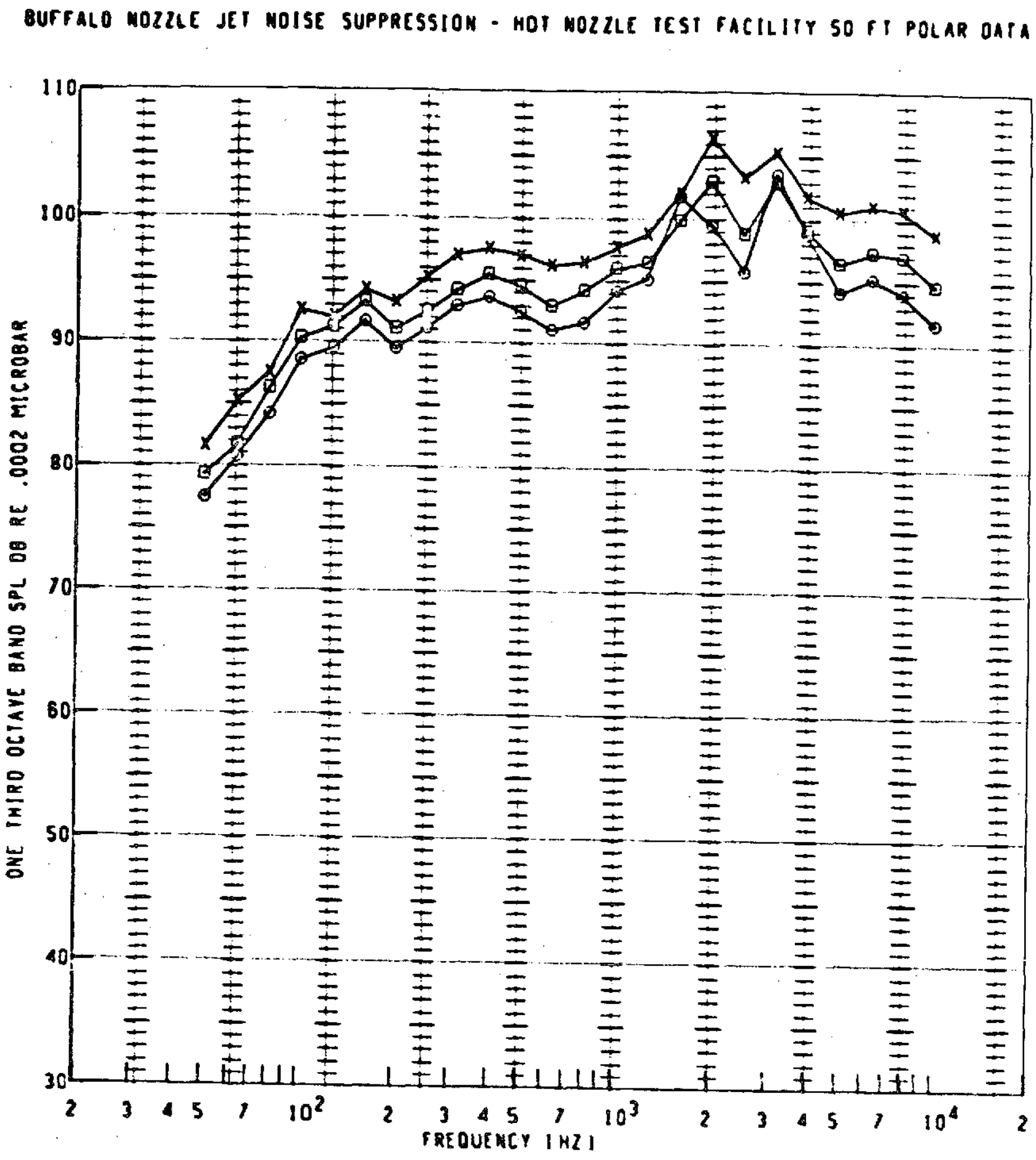
FIGURE 33.--NARROW-BAND ACOUSTICS OF RUN 4 AT 115° ANGLE

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	90G	50FP	108.0	10	750 F
⊡	4	-0	1.400	90G	50FP	110.3	10	800 F
X	4	-0	1.500	90G	50FP	112.0	10	850 F

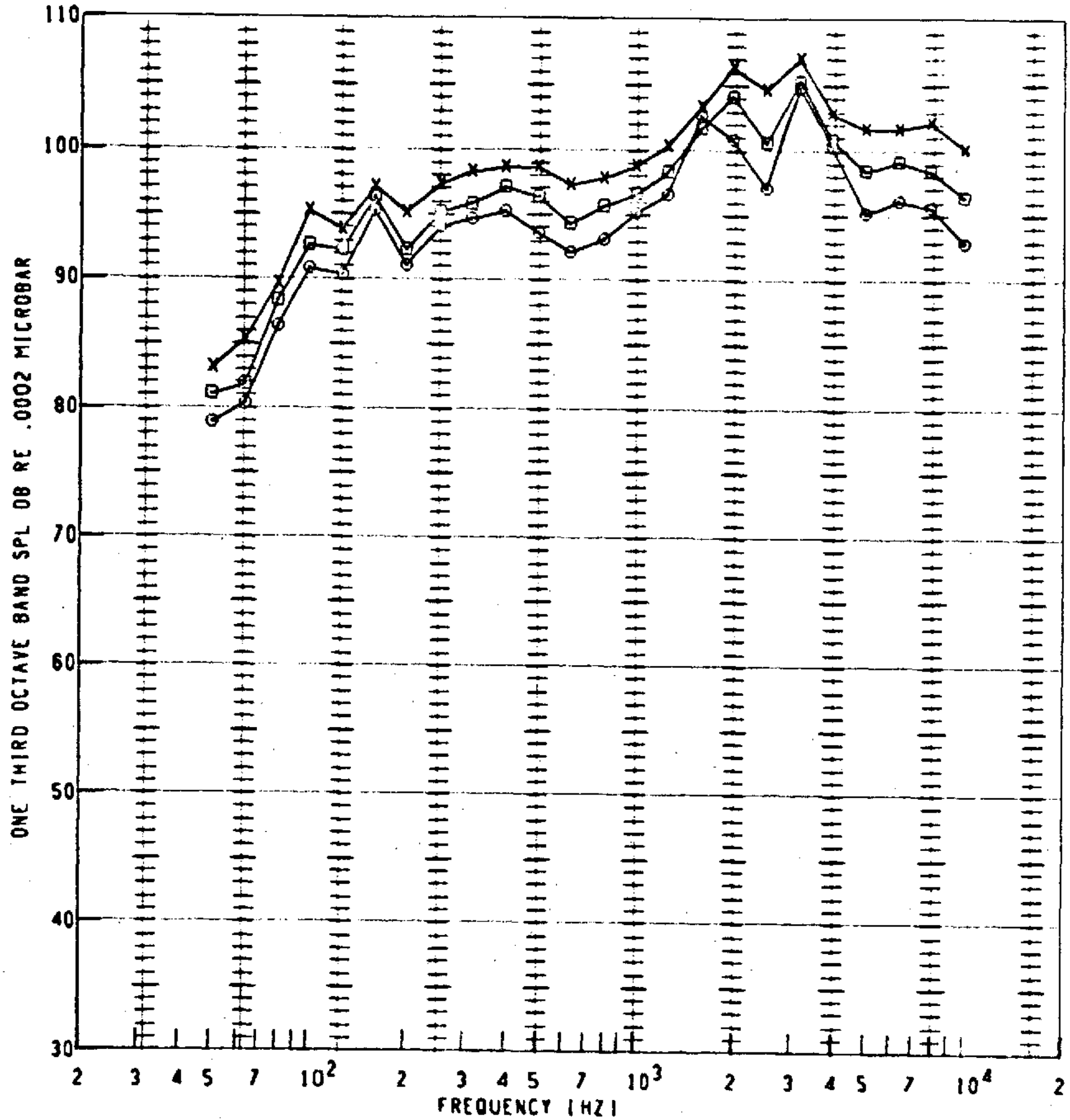
FIGURE 34.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	100G	50FP	109.7	10	750 F
⊡	4	-0	1.400	100G	50FP	111.0	10	800 F
X	4	-0	1.500	100G	50FP	114.0	10	850 F

FIGURE 35.—BUFFALO NOZZLE JET NOISE SUPPRESSION

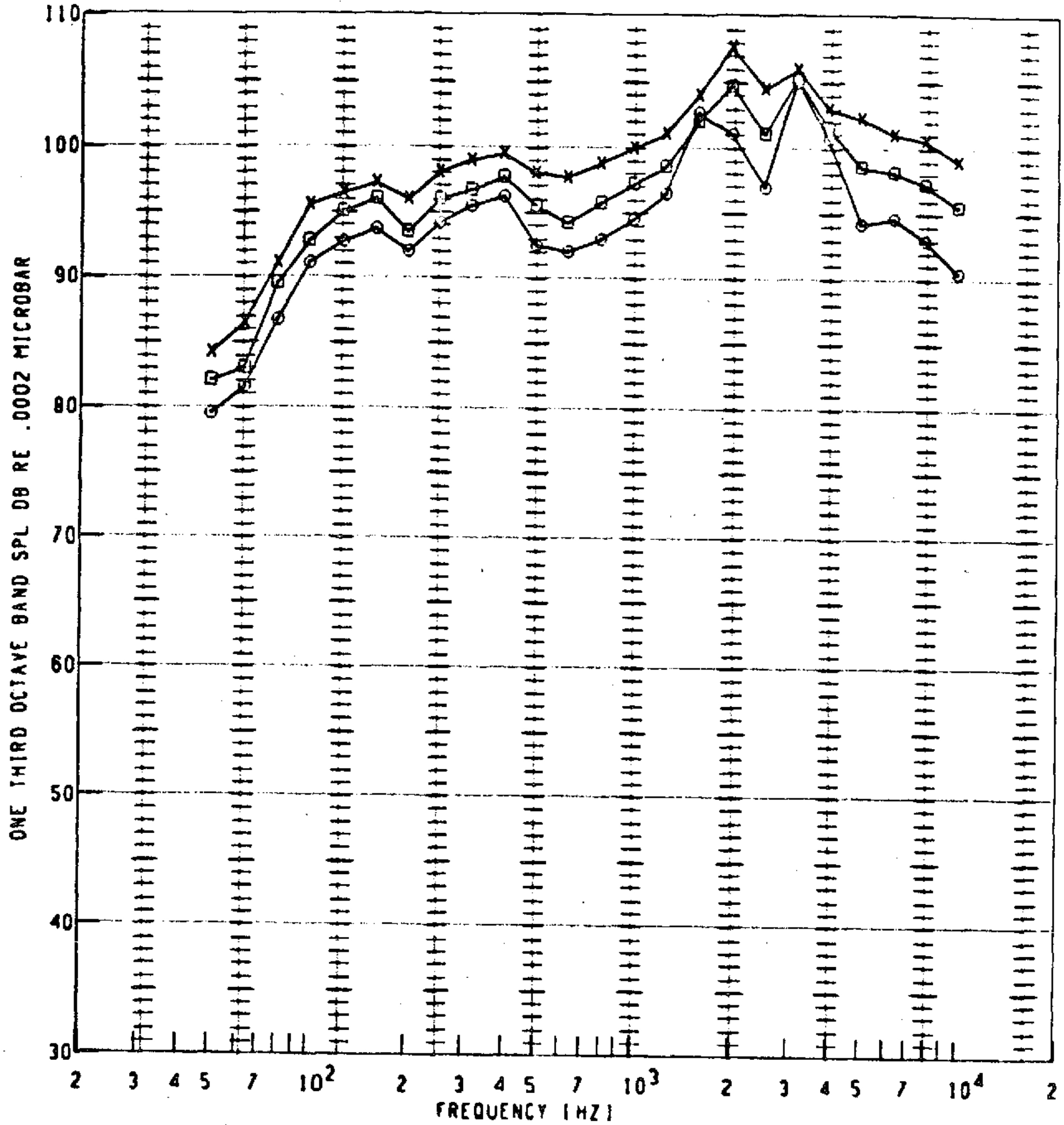
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	110G	50FP	111.1	10	750 F
⊡	4	-0	1.400	110G	50FP	112.3	10	800 F
X	4	-0	1.500	110G	50FP	114.8	10	850 F

FIGURE 36.—BUFFALO NOZZLE JET NOISE SUPPRESSION

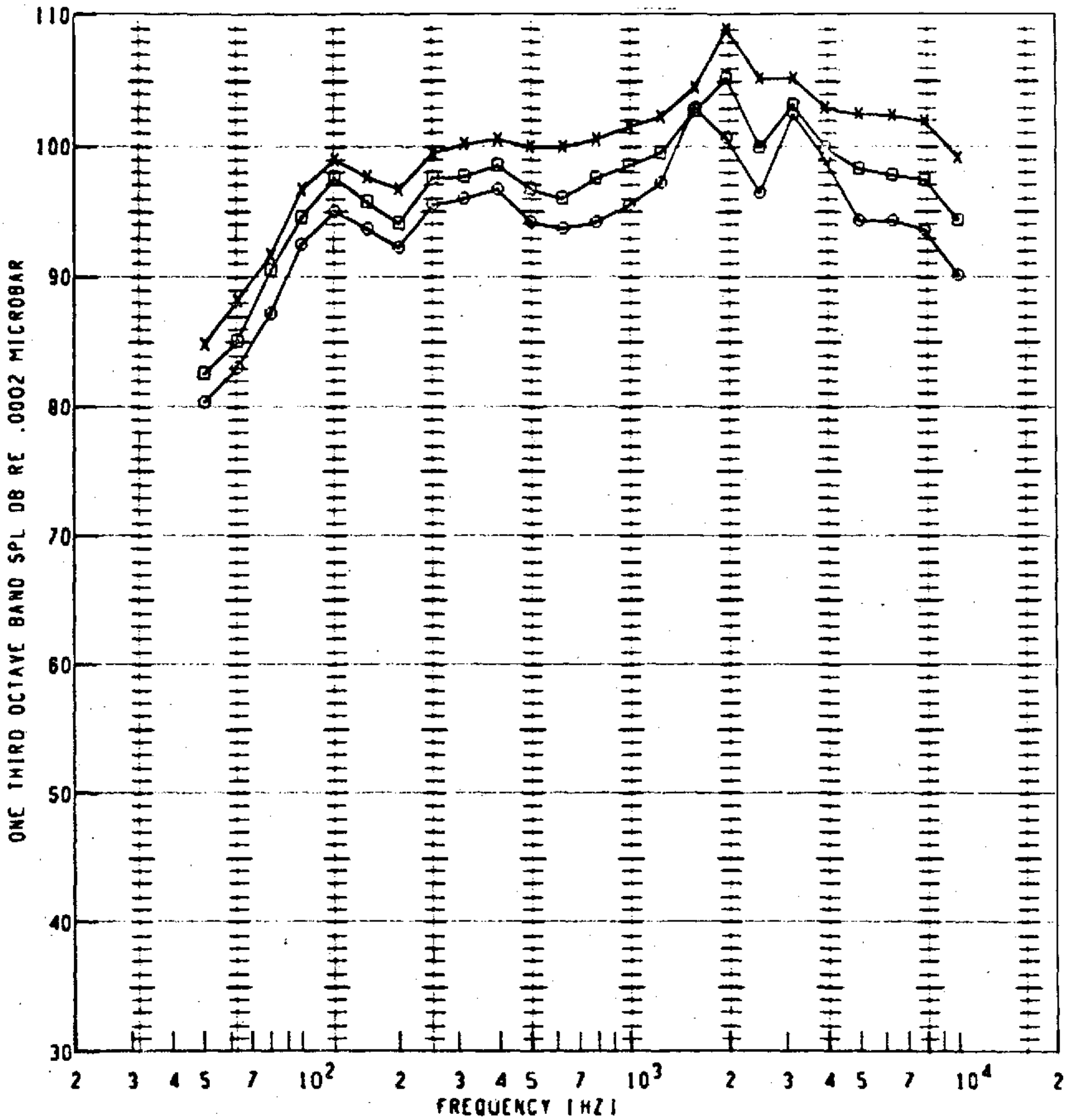
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	115G	50FP	111.2	10	750 F
⊡	4	-0	1.400	115G	50FP	112.5	10	800 F
X	4	-0	1.500	115G	50FP	114.7	10	850 F

FIGURE 37.—BUFFALO NOZZLE JET NOISE SUPPRESSION

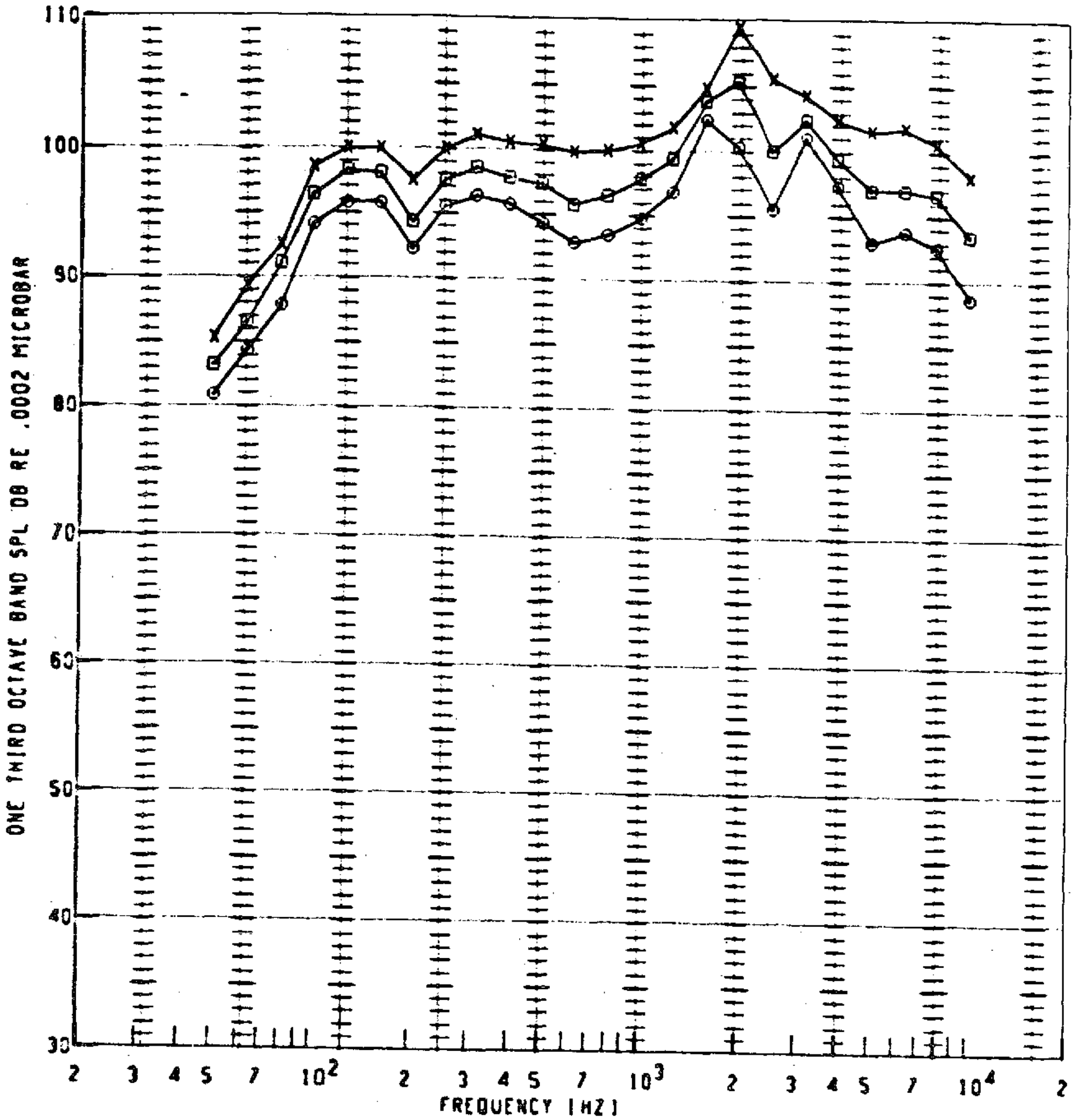
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	120G	50FP	110.5	10	750 F
⊡	4	-0	1.400	120G	50FP	113.0	10	800 F
X	4	-0	1.500	120G	50FP	115.5	10	850 F

FIGURE 38.—BUFFALO NOZZLE JET NOISE SUPPRESSION

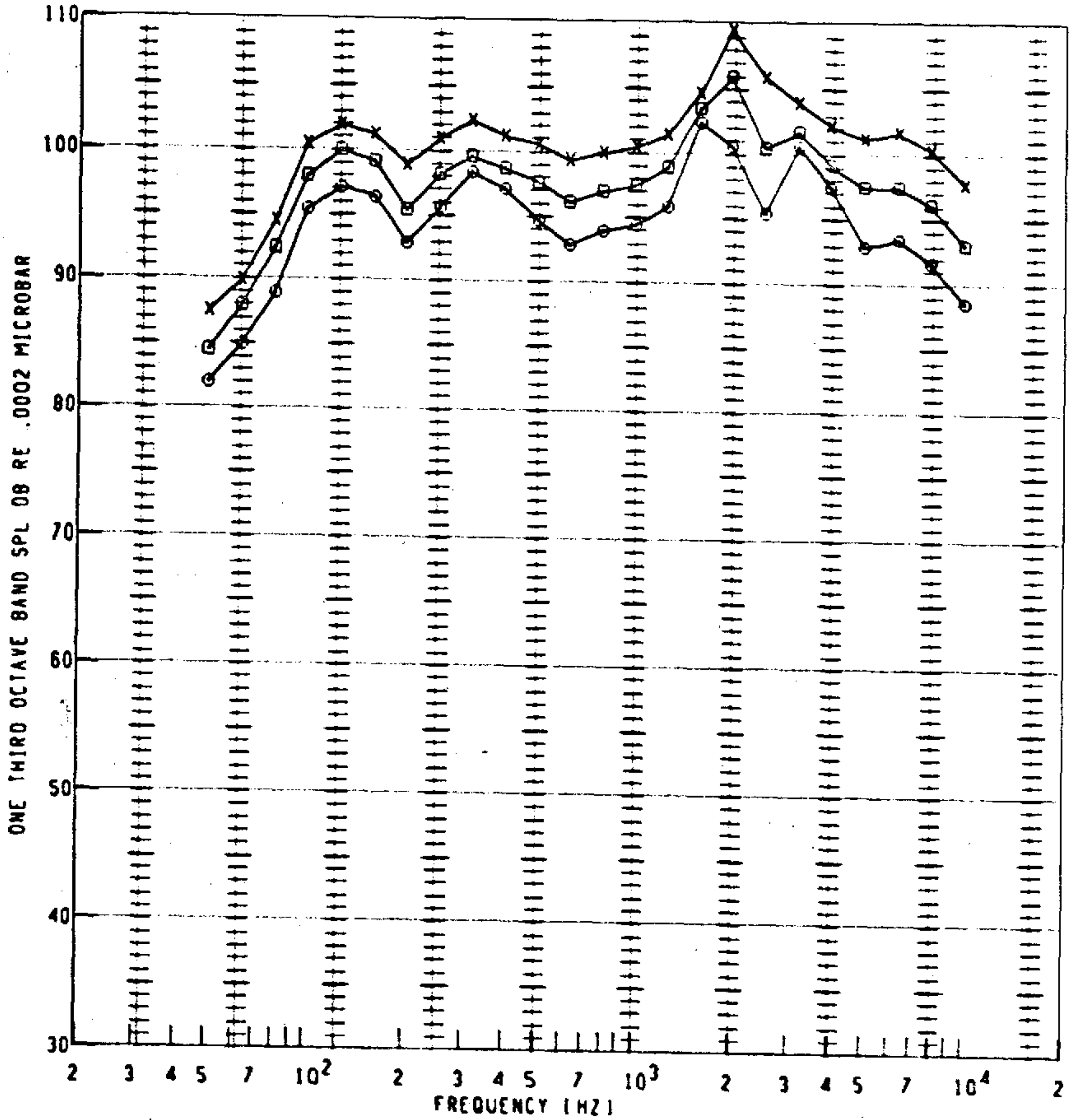
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	4	-0	1.300	125G	50FP	110.3	10	750 F
⊡	4	-0	1.400	125G	50FP	112.5	10	800 F
X	4	-0	1.500	125G	50FP	115.5	10	850 F

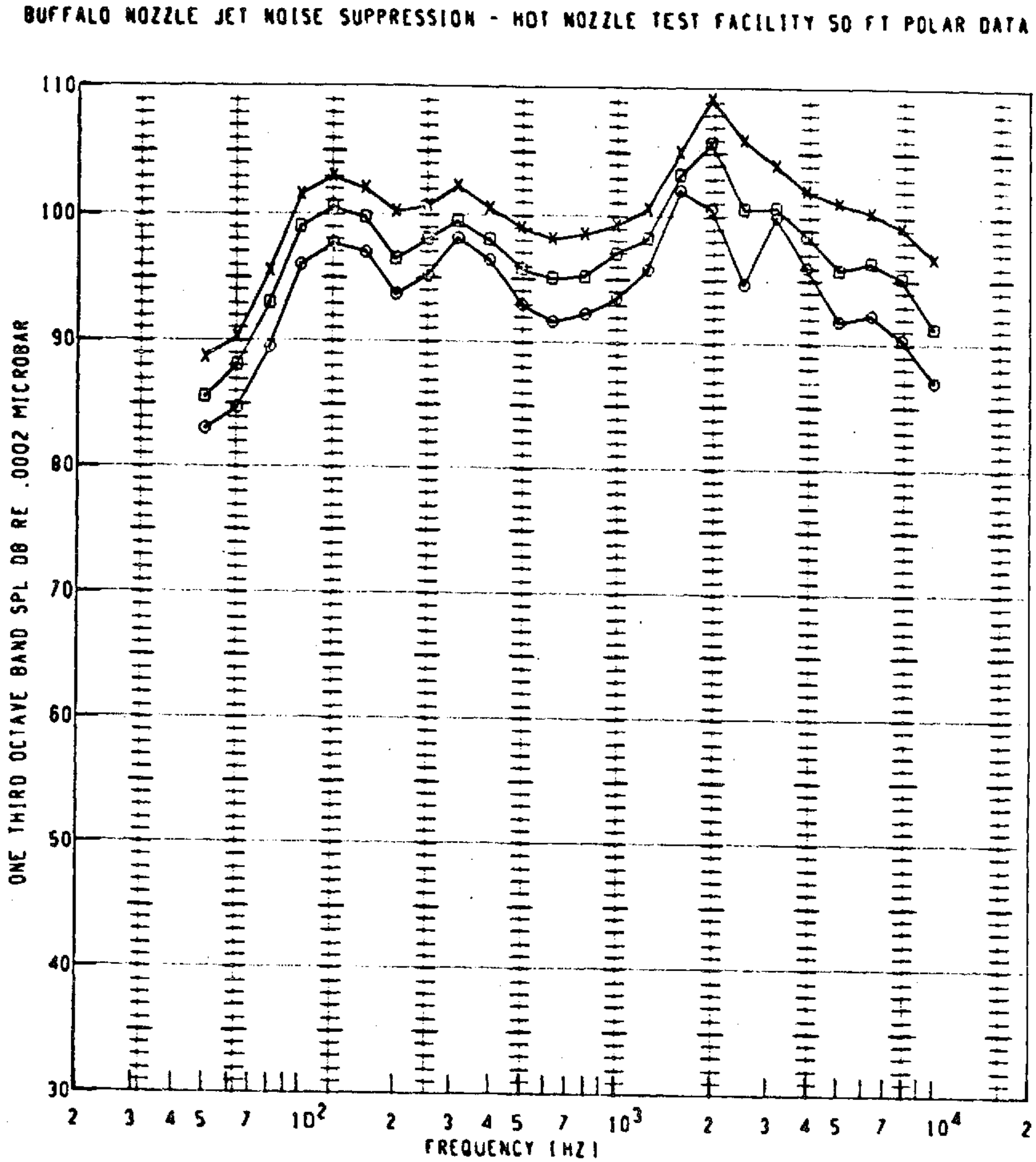
FIGURE 39.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	130G	50FP	110.9	10	750 F
⊡	4	-0	1.400	130G	50FP	112.6	10	800 F
X	4	-0	1.500	130G	50FP	115.9	10	850 F

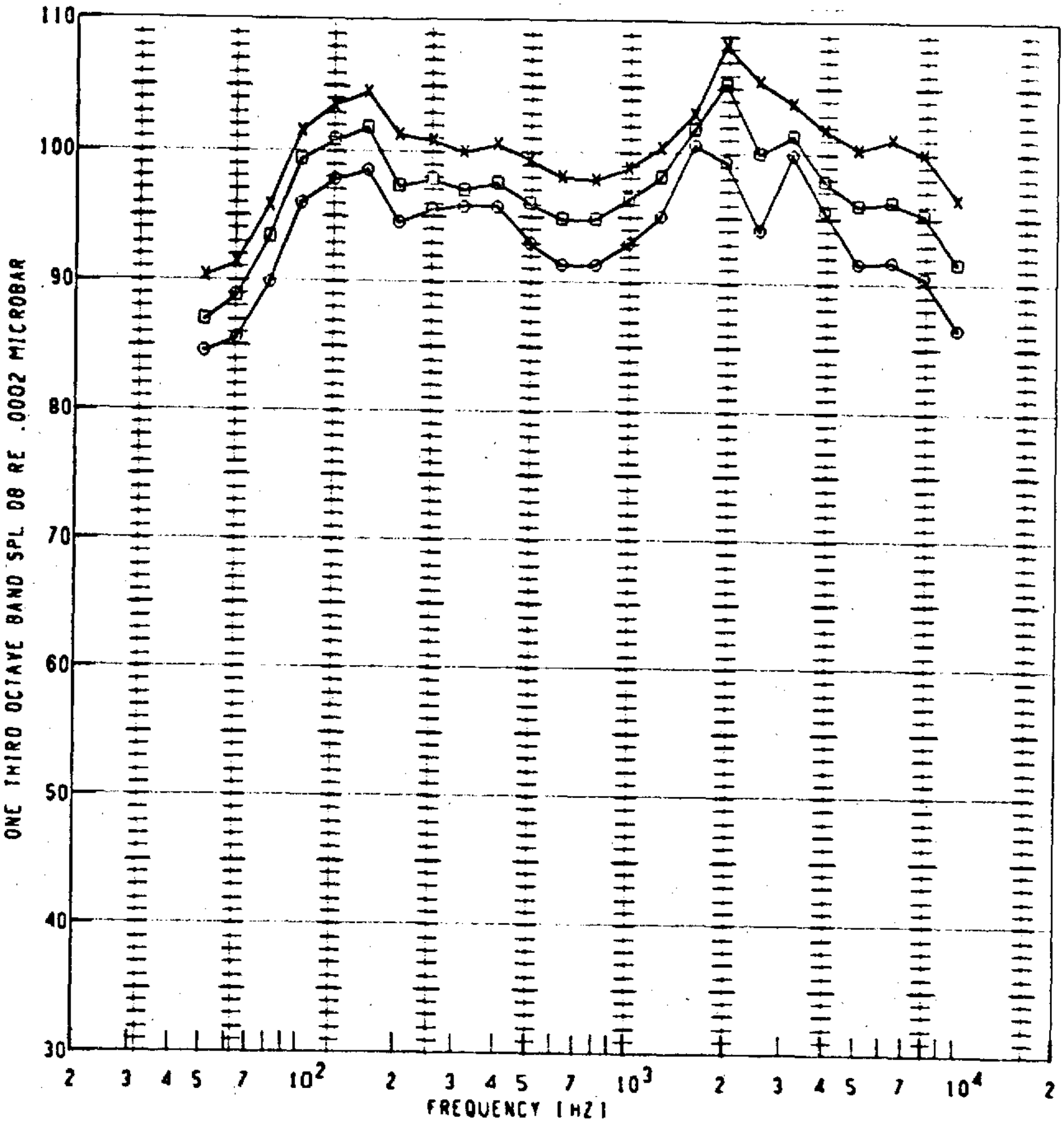
FIGURE 40.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	135G	50FP	110.0	10	750 F
⊡	4	-0	1.400	135G	50FP	112.2	10	800 F
X	4	-0	1.500	135G	50FP	116.0	10	850 F

FIGURE 41.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	4	-0	1.300	140G	50FP	109.3	10	750 F
⊡	4	-0	1.400	140G	50FP	112.3	10	800 F
X	4	-0	1.500	140G	50FP	115.8	10	850 F

FIGURE 42.—BUFFALO NOZZLE JET NOISE SUPPRESSION

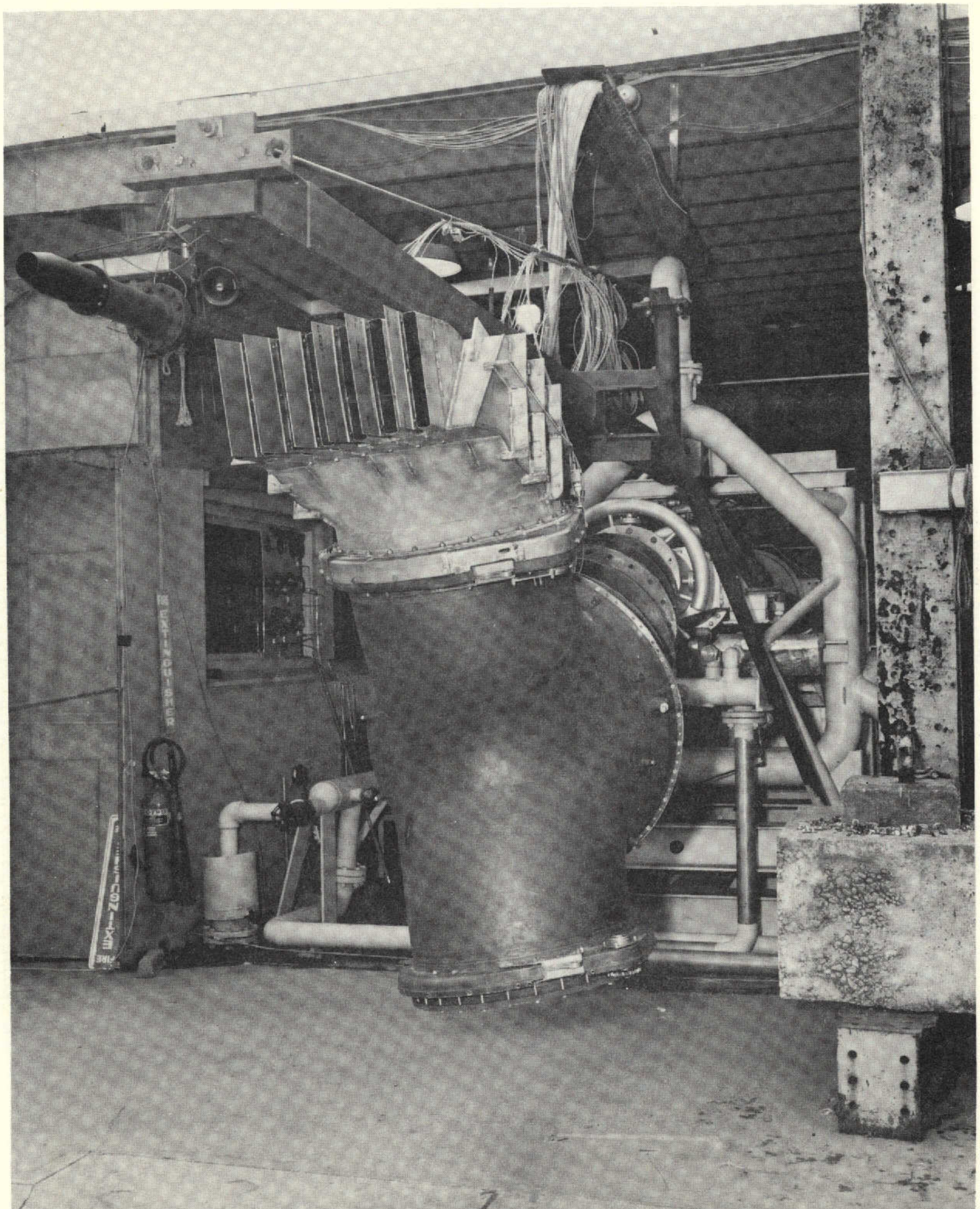


FIGURE 43.—12.7 cm (5-in.) FENCES ATTACHED TO LOBE WALLS

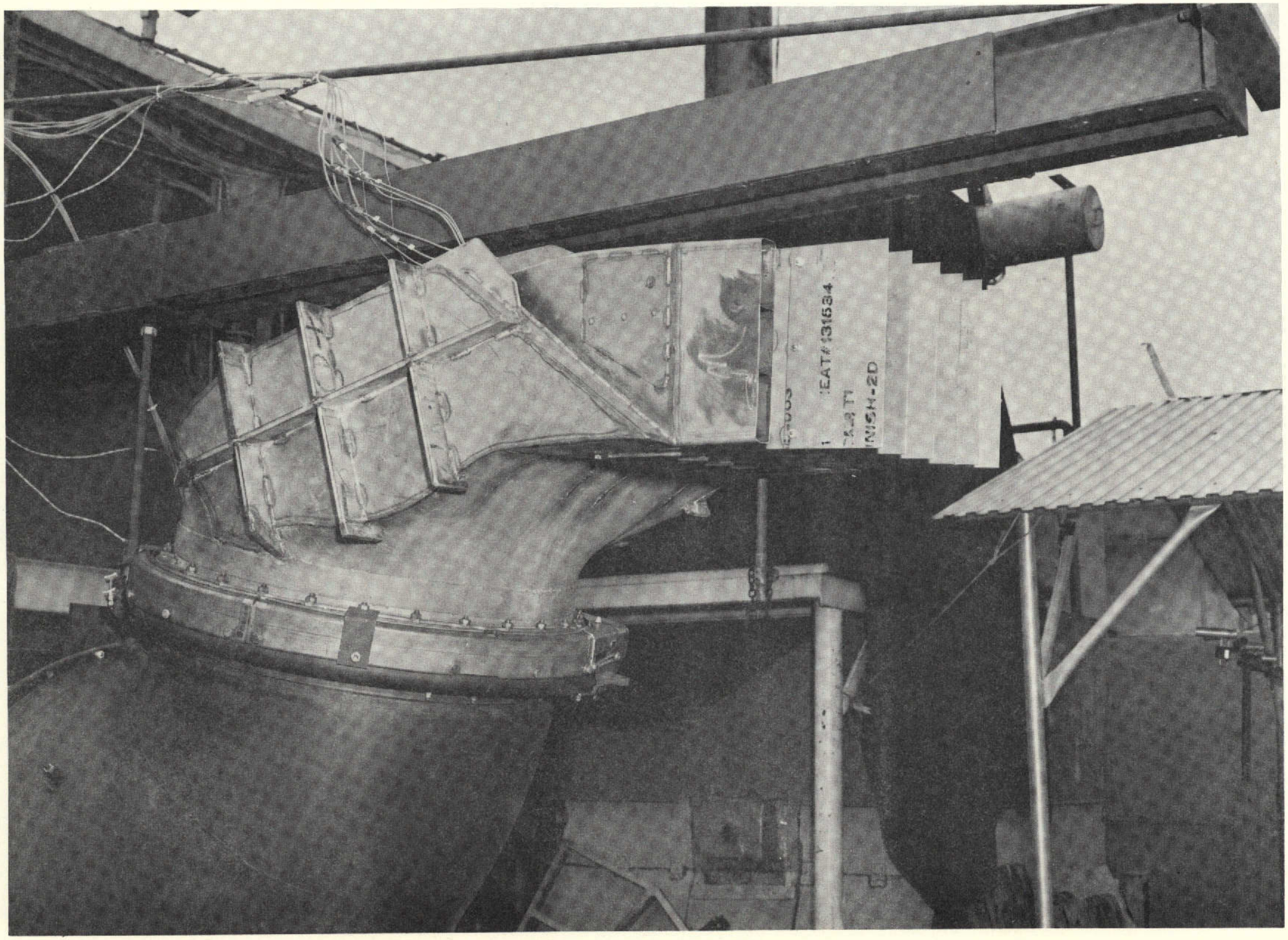


FIGURE 44.—12.7 cm (5-in.) FENCES ATTACHED TO LOBE WALLS

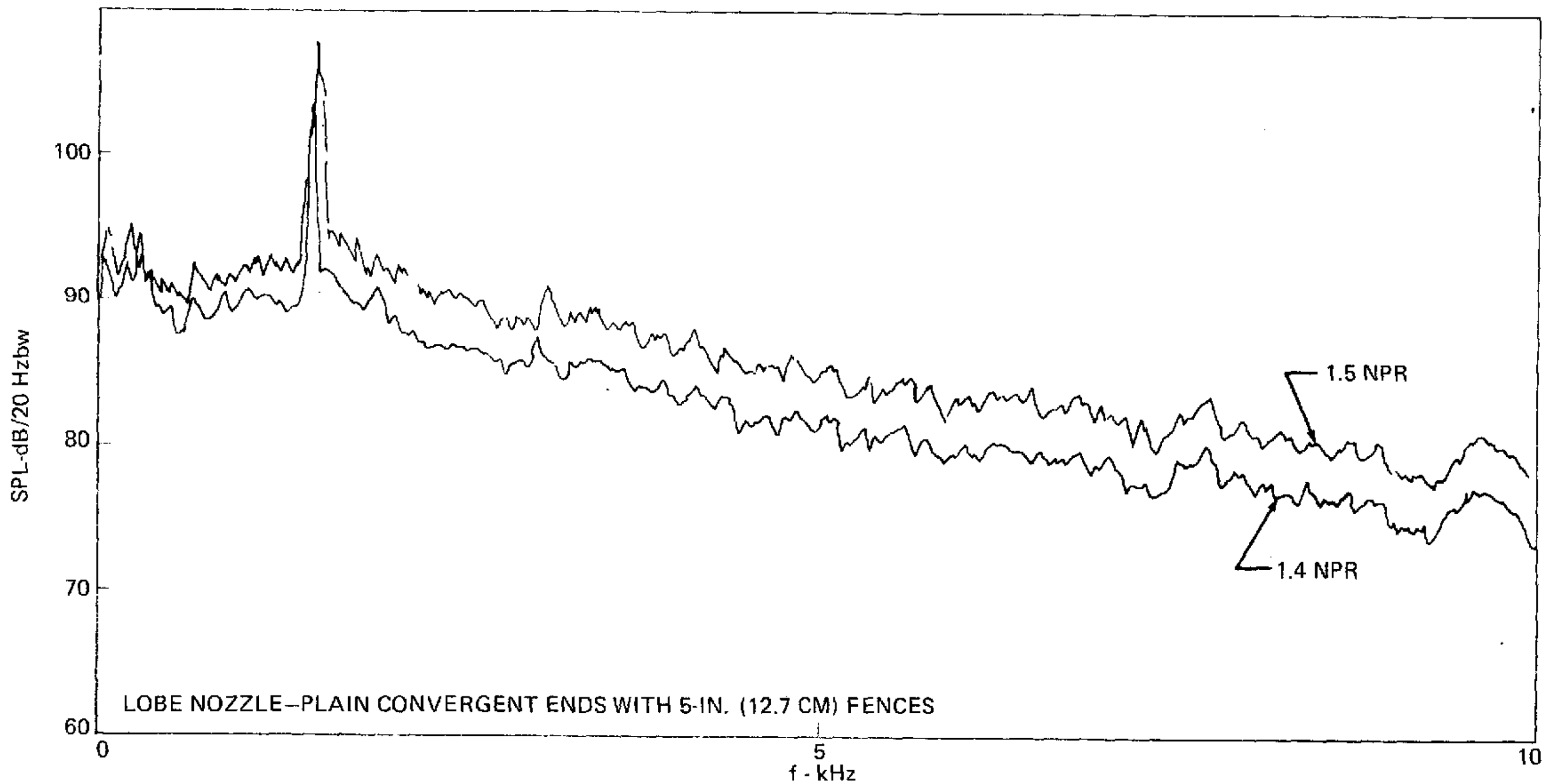
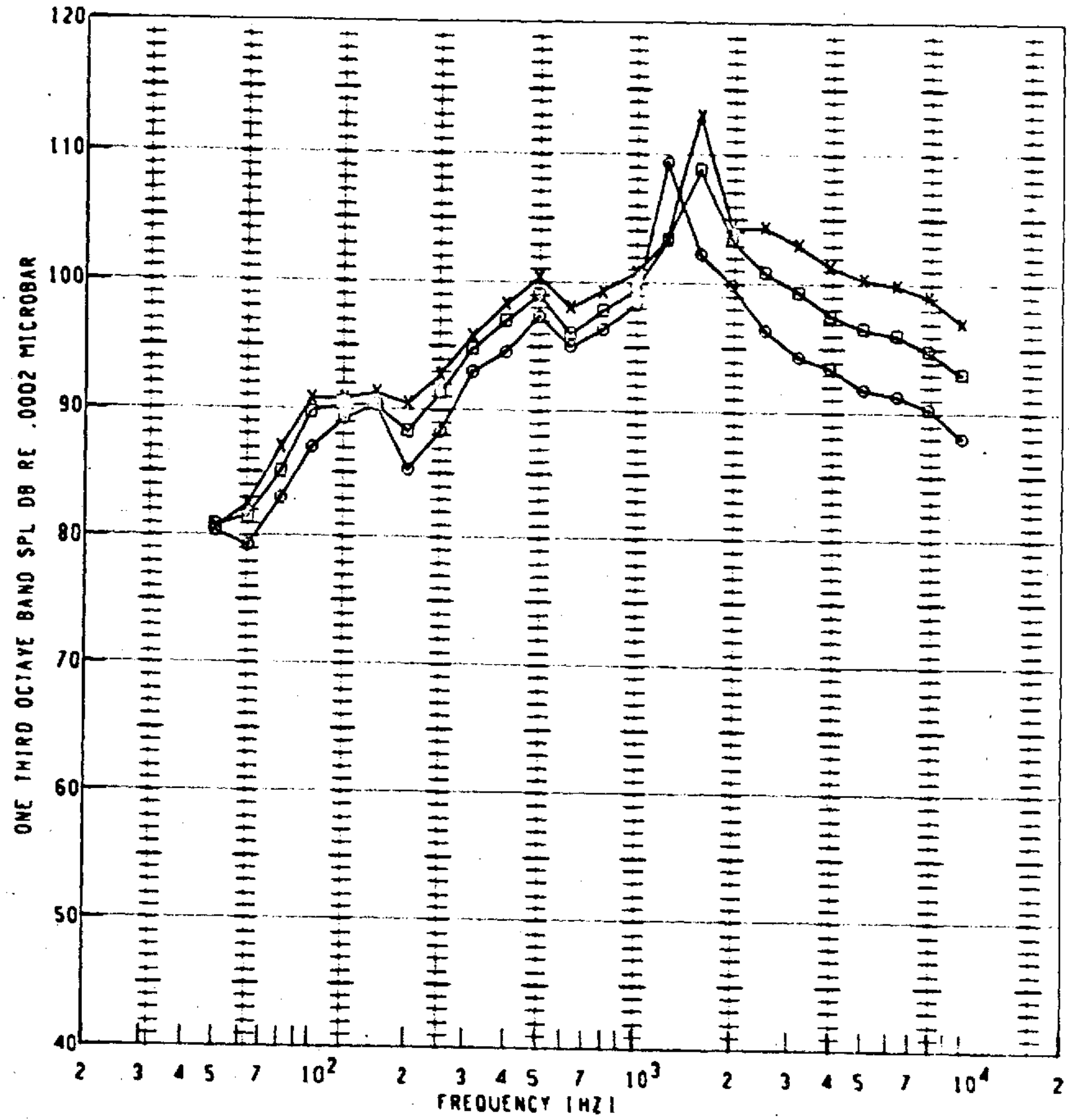


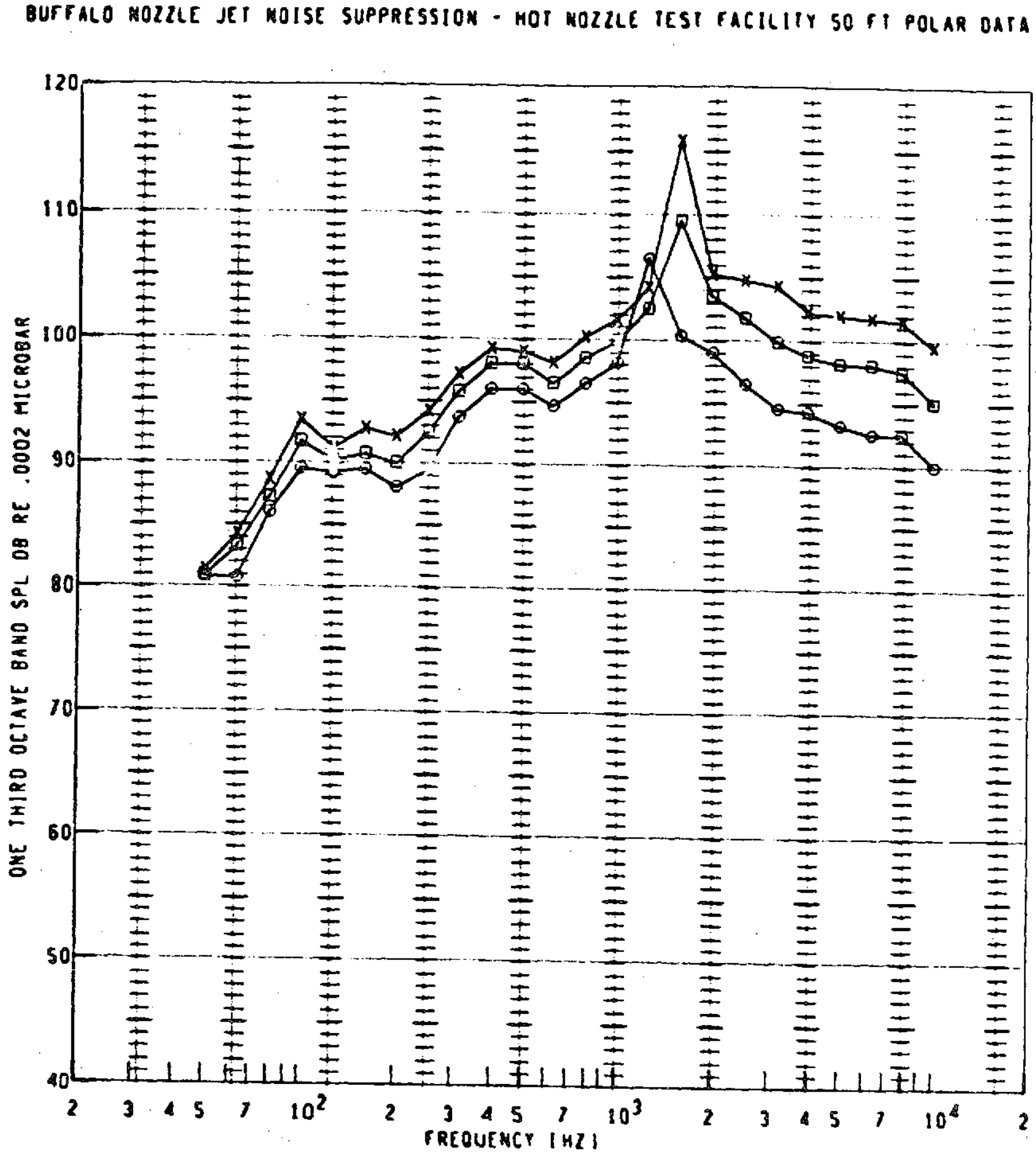
FIGURE 45.–NARROW-BAND ACOUSTICS OF RUN 5 AT 115° ANGLE

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	90G	50FP	112.0	10	750 F
⊡	5	-0	1.400	90G	50FP	113.0	10	800 F
x	5	-0	1.500	90G	50FP	116.3	10	850 F

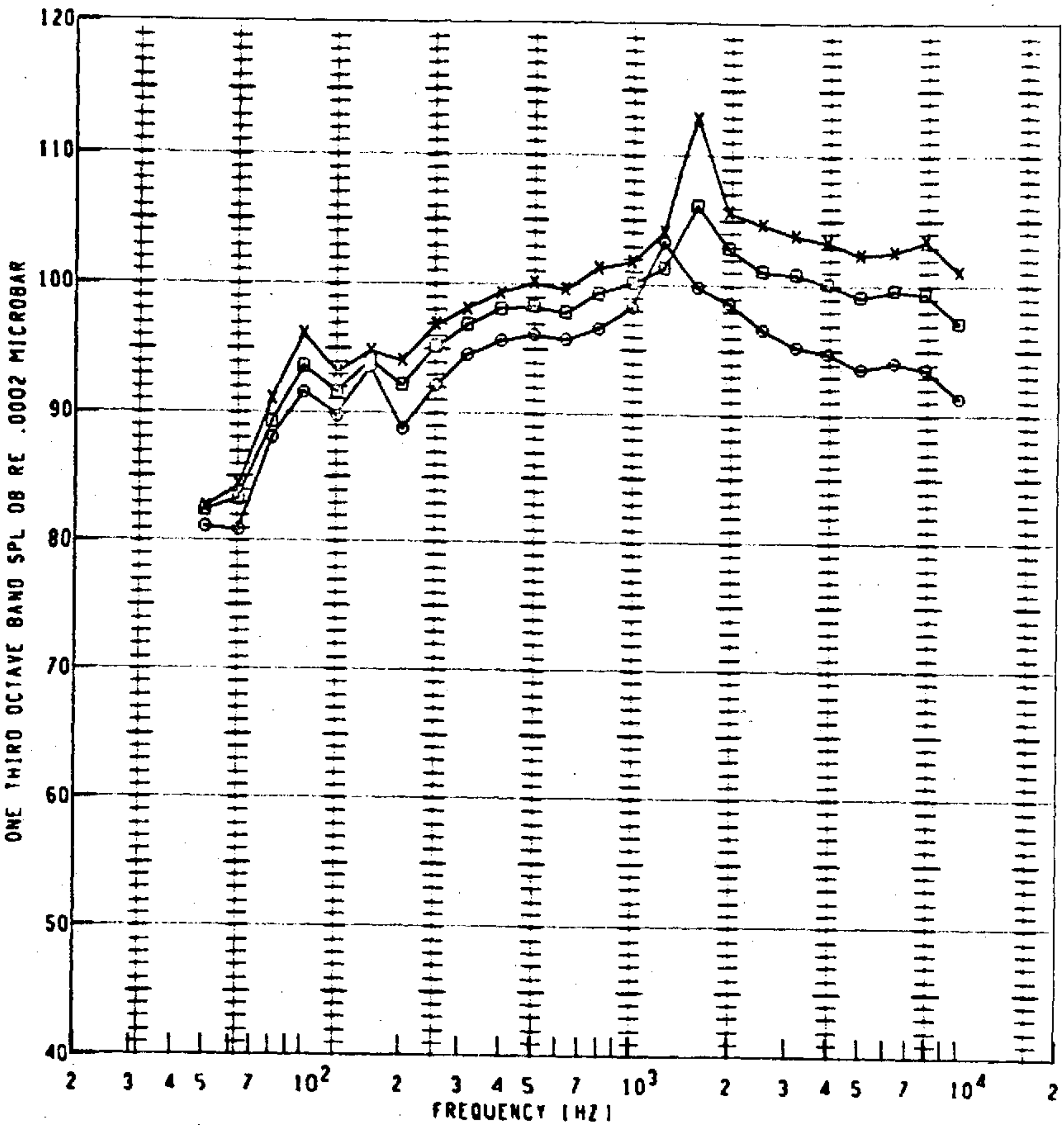
FIGURE 46.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL IO
⊙	5	-0	1.300	100G	50FP	110.7	10	750 F
⊡	5	-0	1.400	100G	50FP	114.0	10	800 F
X	5	-0	1.500	100G	50FP	118.0	10	850 F

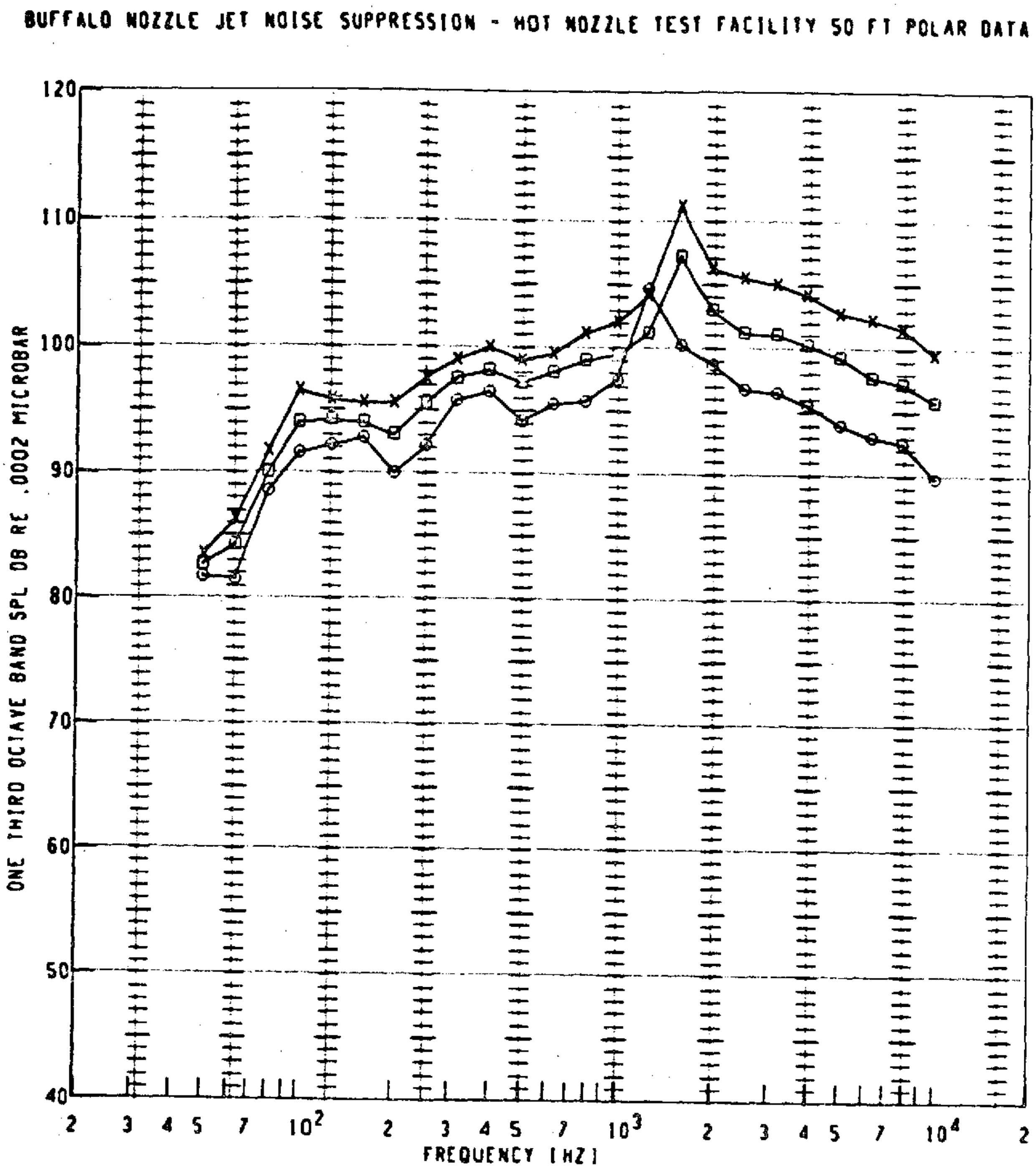
FIGURE 47.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



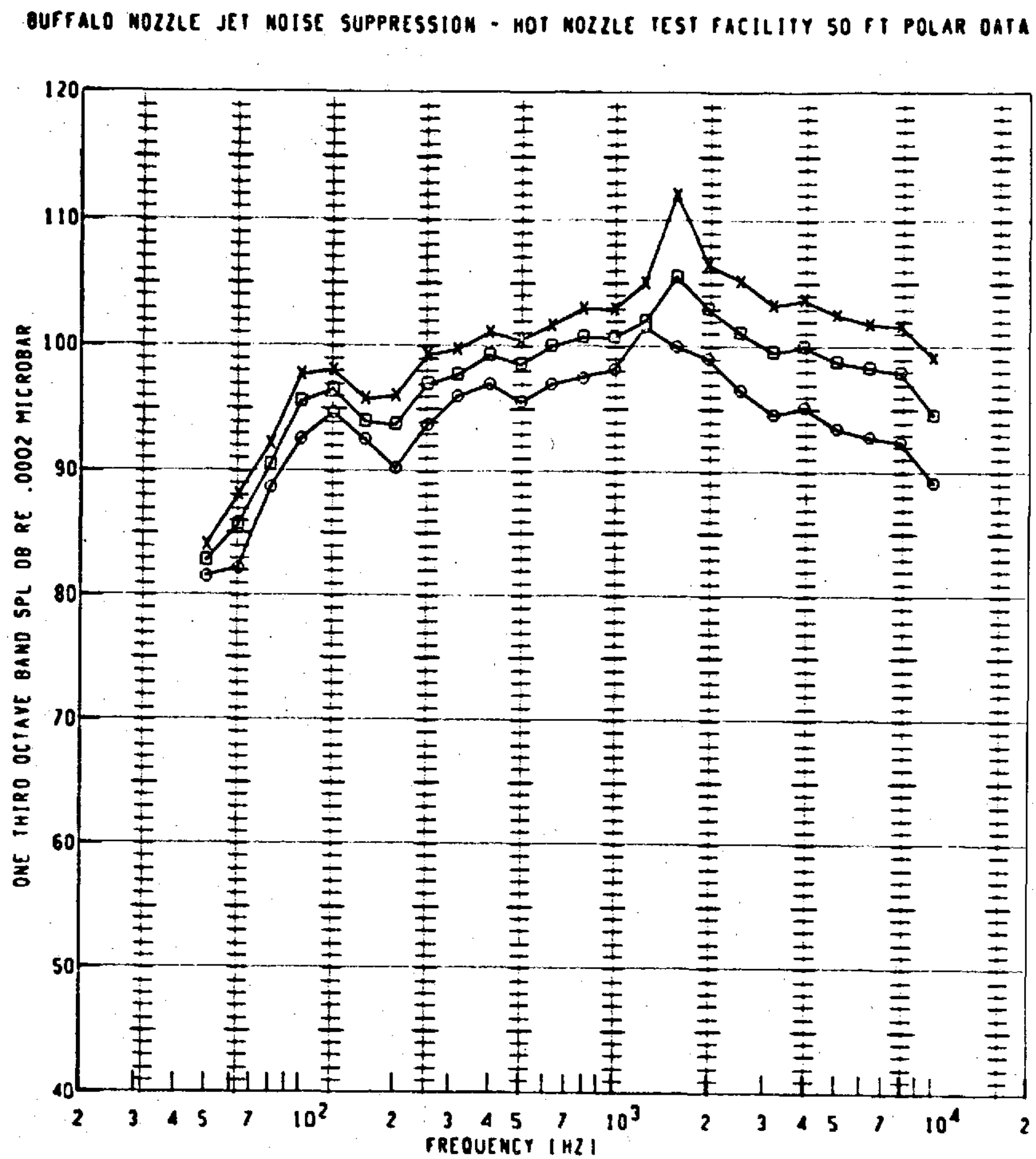
PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	110G	50FP	109.8	10	750 F
⊡	5	-0	1.400	110G	50FP	113.3	10	800 F
x	5	-0	1.500	110G	50FP	117.1	10	850 F

FIGURE 48.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	115G	50FP	110.2	10	750 F
⊡	5	-0	1.400	115G	50FP	113.0	10	800 F
X	5	-0	1.500	115G	50FP	116.7	10	850 F

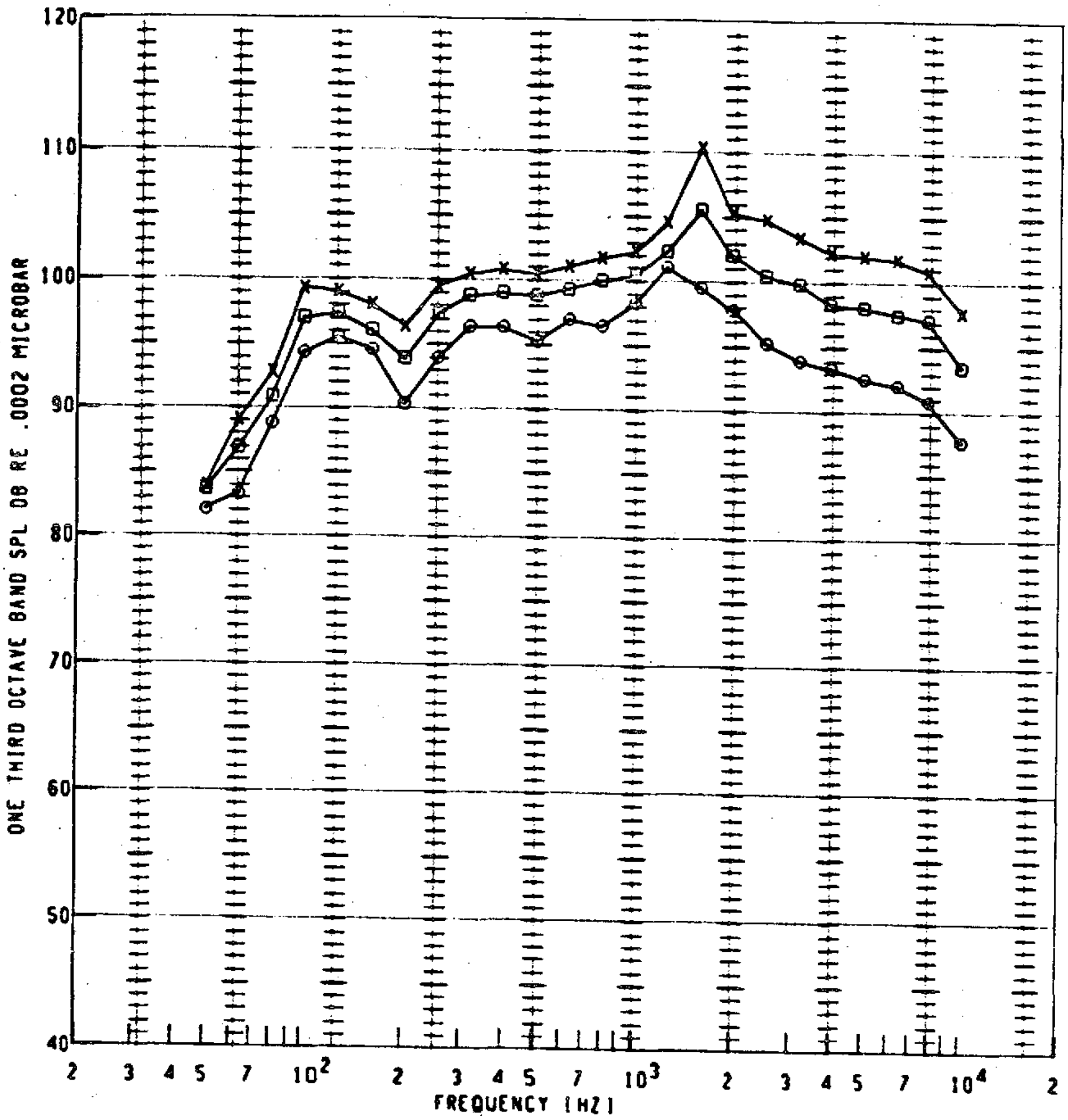
FIGURE 49.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	120G	50FP	110.0	10	750 F
⊡	5	-0	1.400	120G	50FP	113.0	10	800 F
X	5	-0	1.500	120G	50FP	117.2	10	850 F

FIGURE 50.—BUFFALO NOZZLE JET NOISE SUPPRESSION

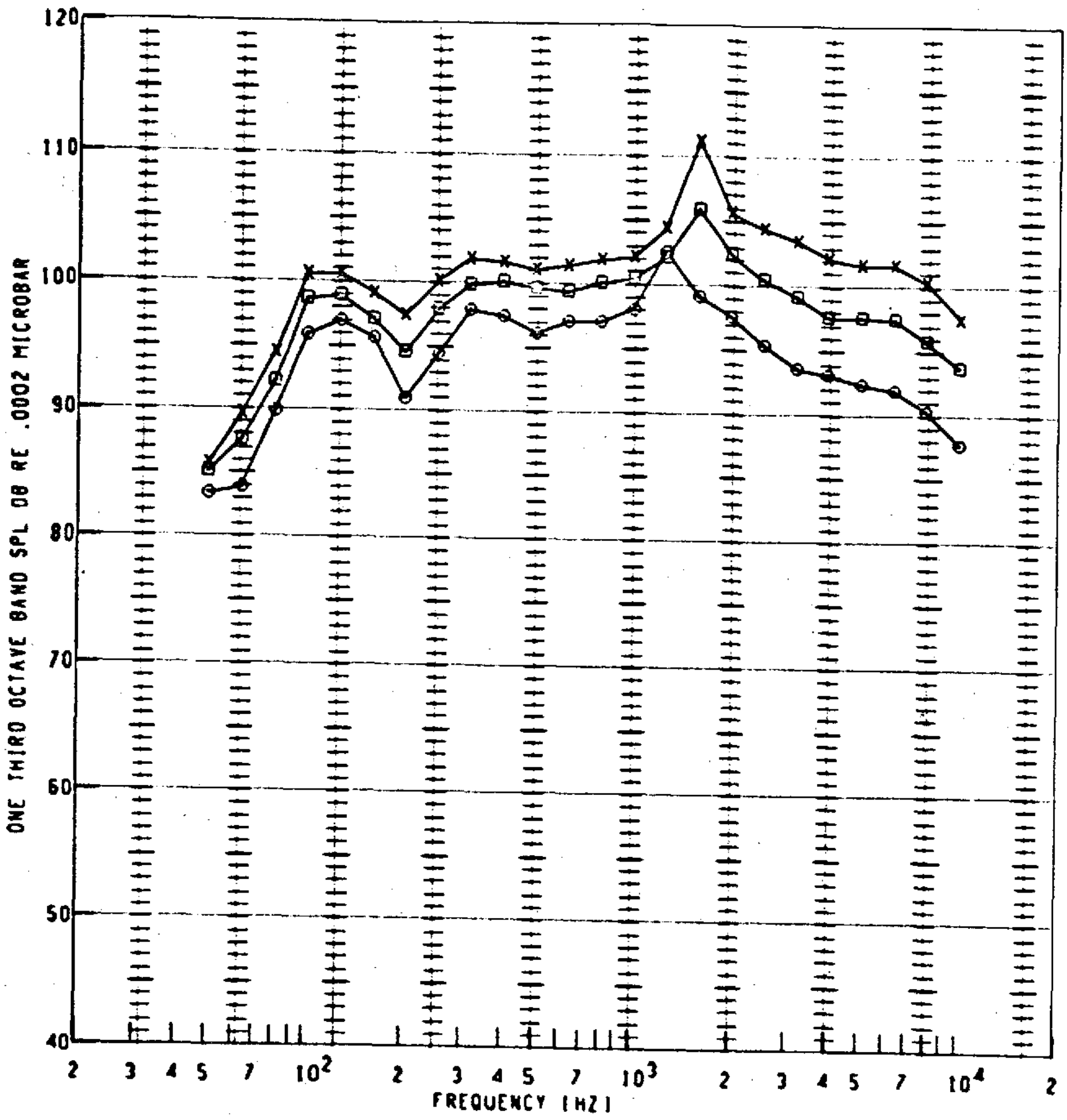
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	125G	50FP	109.8	10	750 F
⊡	5	-0	1.400	125G	50FP	113.0	10	800 F
X	5	-0	1.500	125G	50FP	116.0	10	850 F

FIGURE 51.—BUFFALO NOZZLE JET NOISE SUPPRESSION

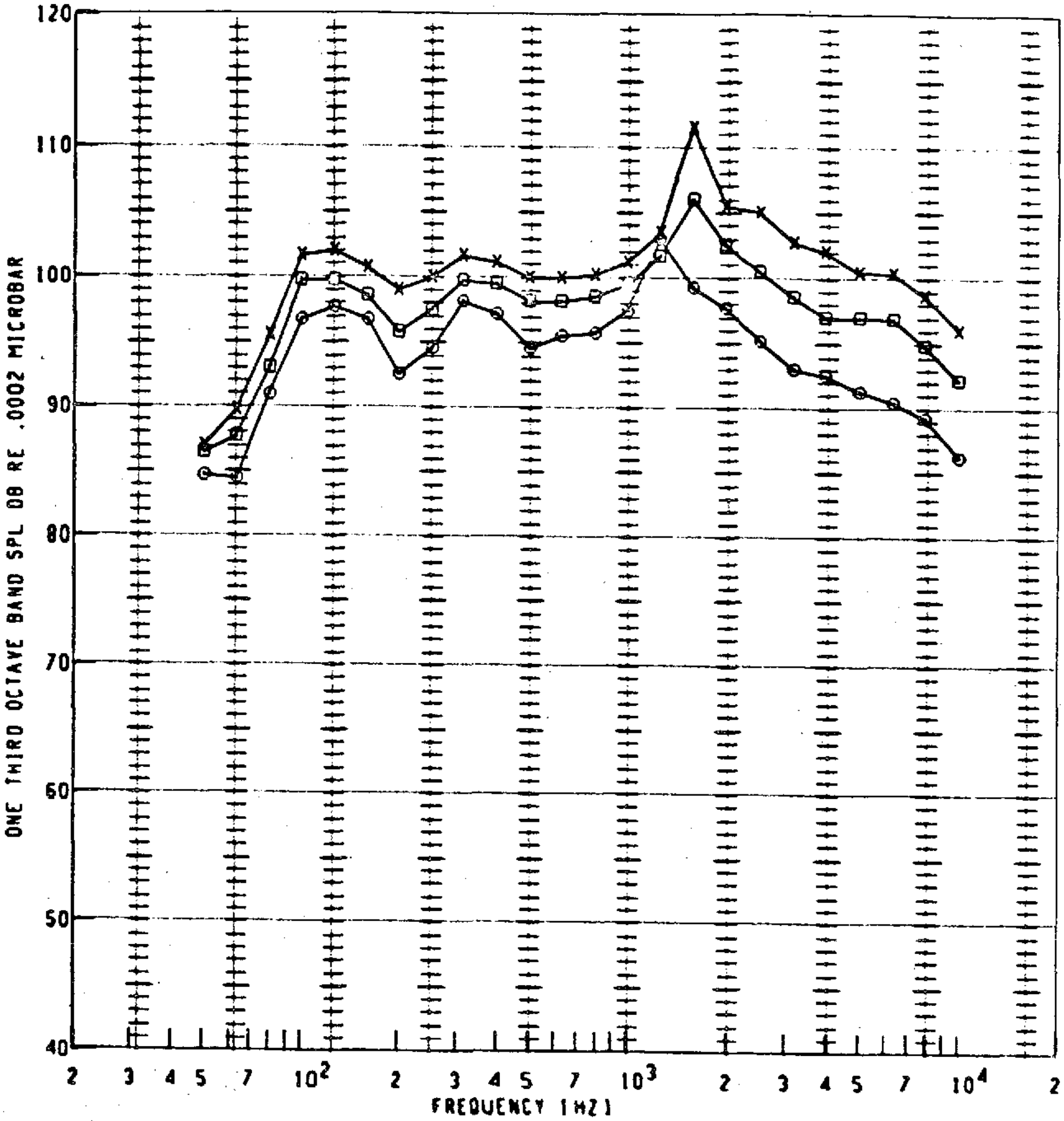
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	130G	50FP	109.9	10	750 F
⊡	5	-0	1.400	130G	50FP	112.9	10	800 F
X	5	-0	1.500	130G	50FP	116.9	10	850 F

FIGURE 52.—BUFFALO NOZZLE JET NOISE SUPPRESSION

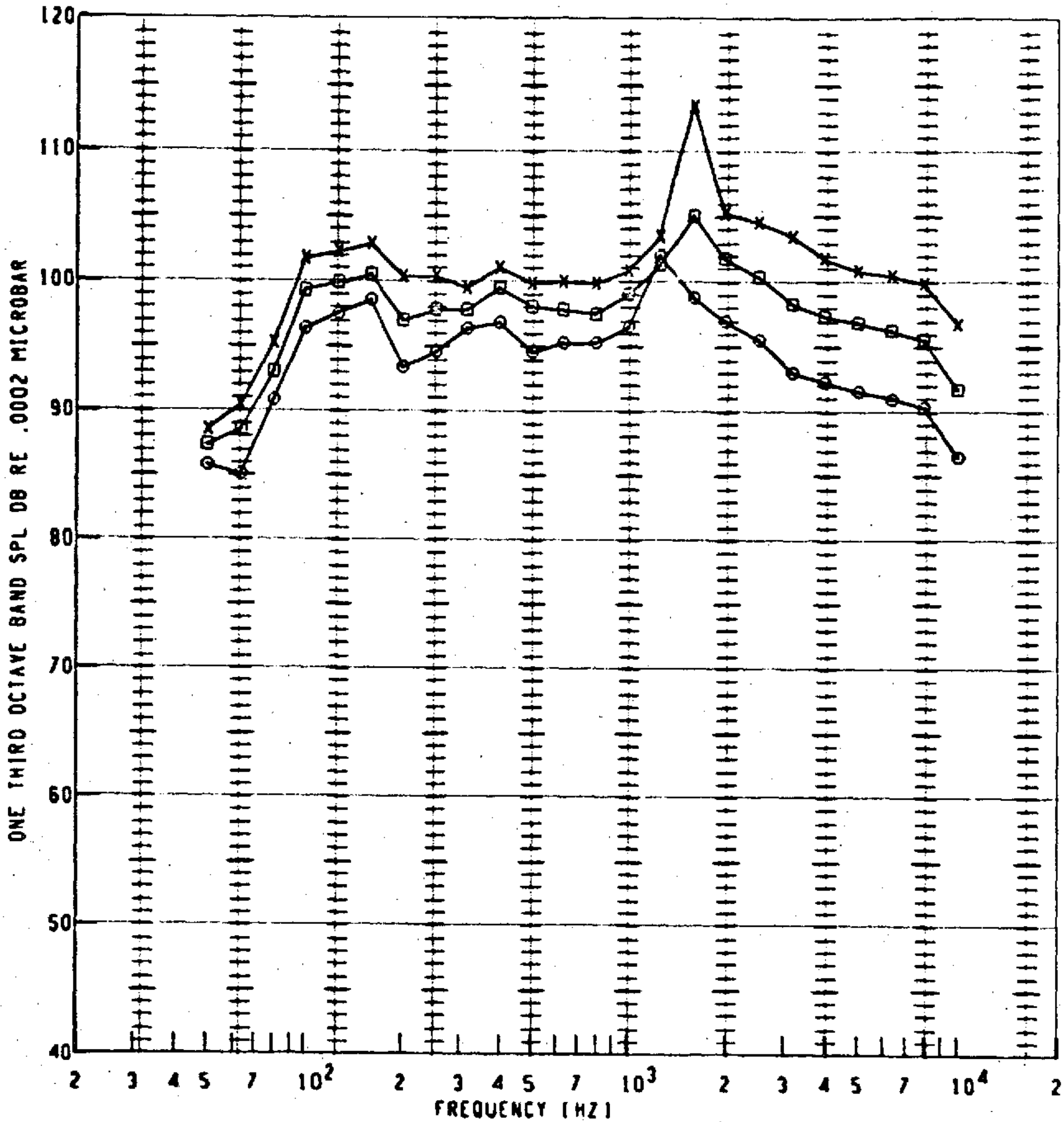
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	135G	50FP	109.7	10	750 F
⊡	5	-0	1.400	135G	50FP	113.0	10	800 F
X	5	-0	1.500	135G	50FP	116.7	10	850 F

FIGURE 53.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	5	-0	1.300	140G	50FP	109.5	10	750 F
⊡	5	-0	1.400	140G	50FP	112.5	10	800 F
X	5	-0	1.500	140G	50FP	117.5	10	850 F

FIGURE 54.—BUFFALO NOZZLE JET NOISE SUPPRESSION

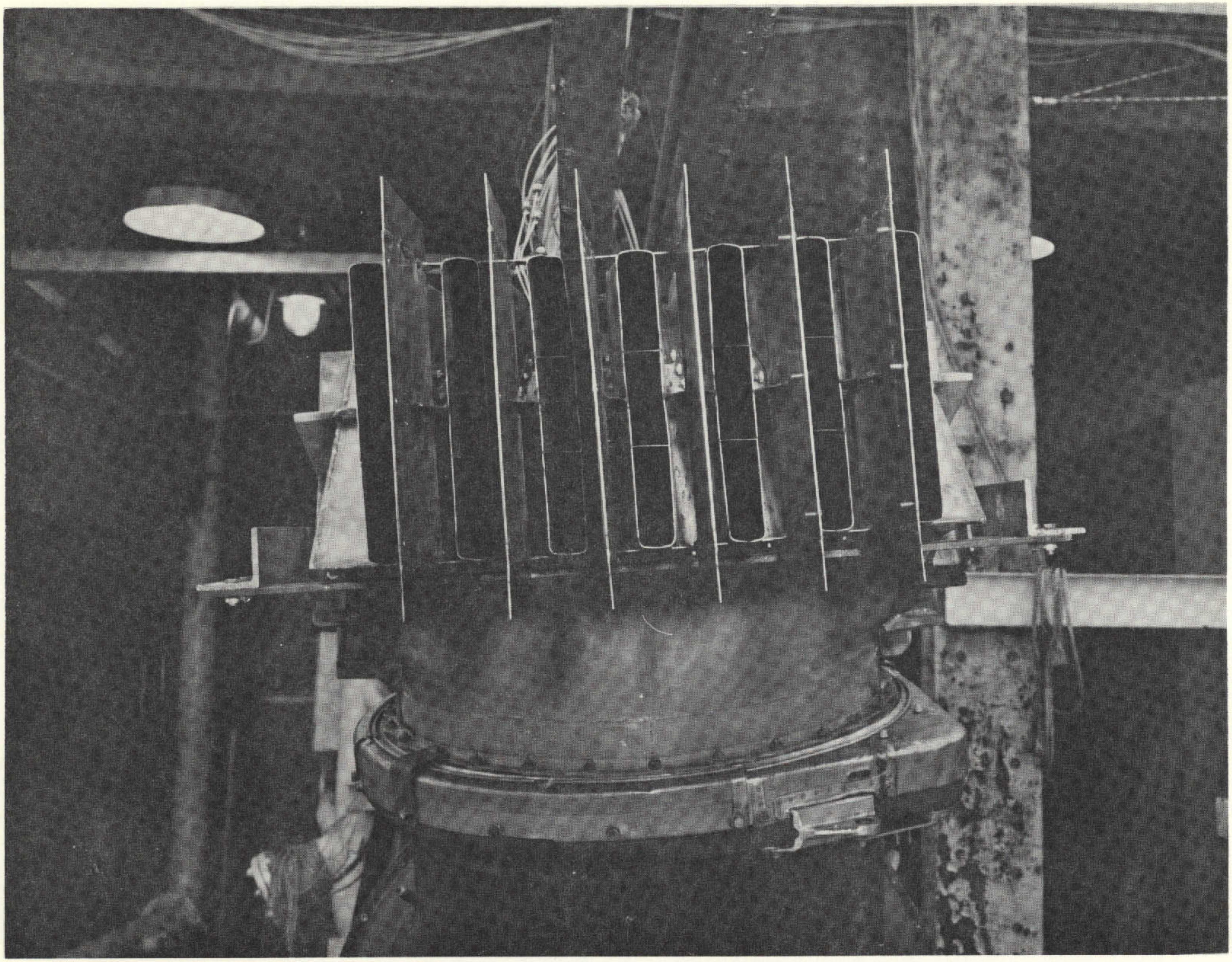


FIGURE 55.– 12.7 cm (5-in.) FENCES (SPLITTERS) LOCATED IN CENTER OF SECONDARY PASSAGES

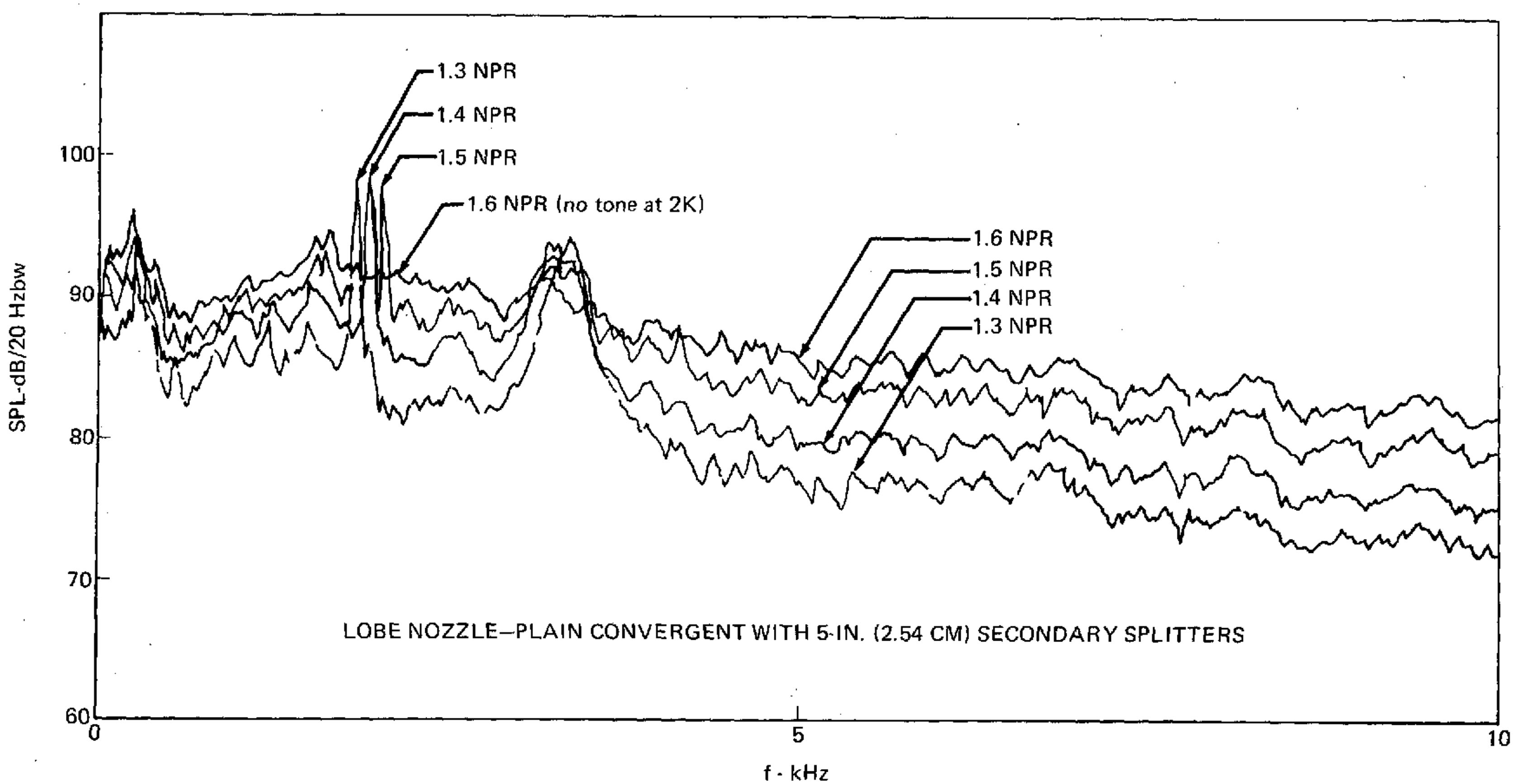
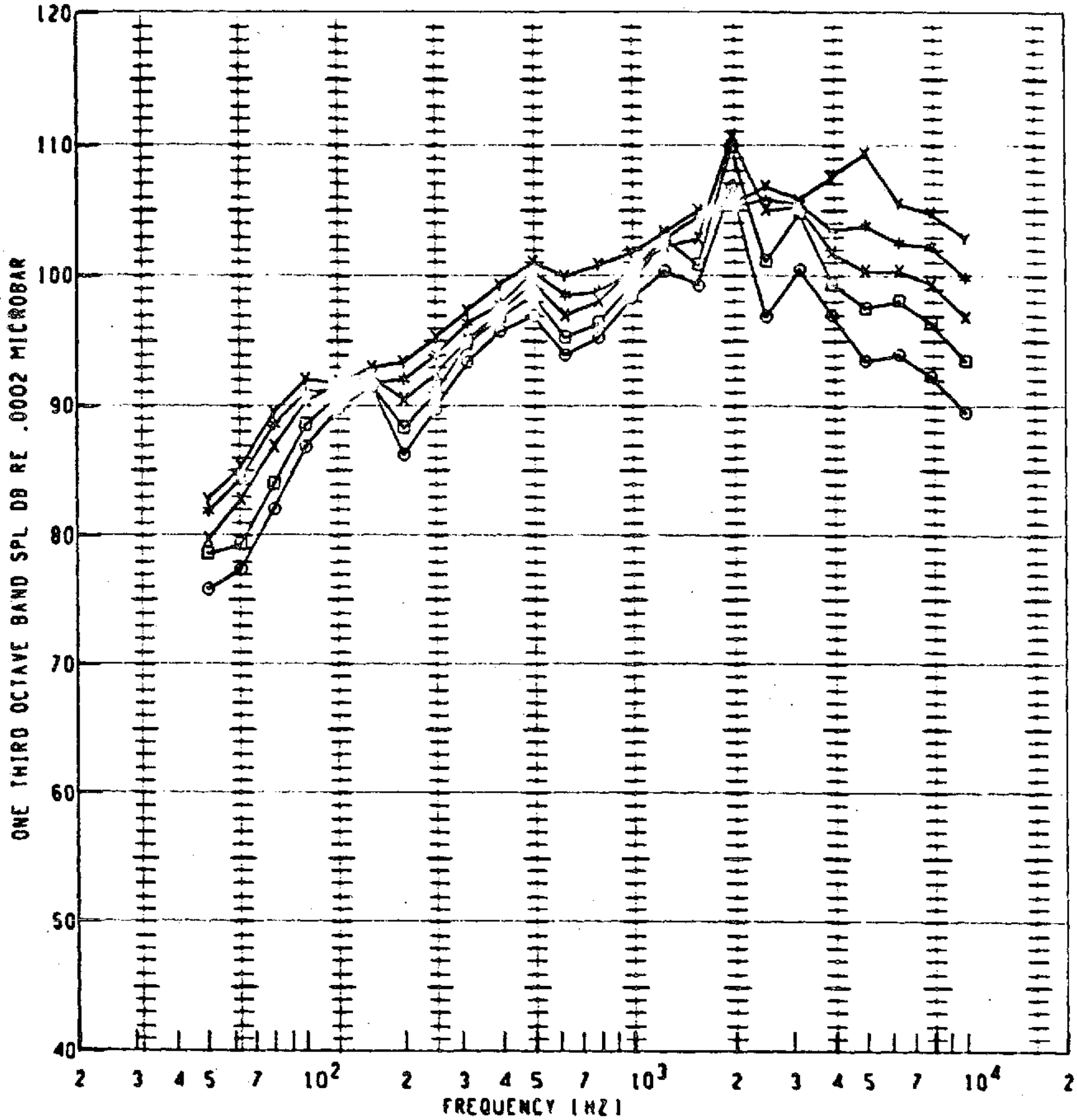


FIGURE 56.—NARROW-BAND ACOUSTICS OF RUN 6 AT 115° ANGLE

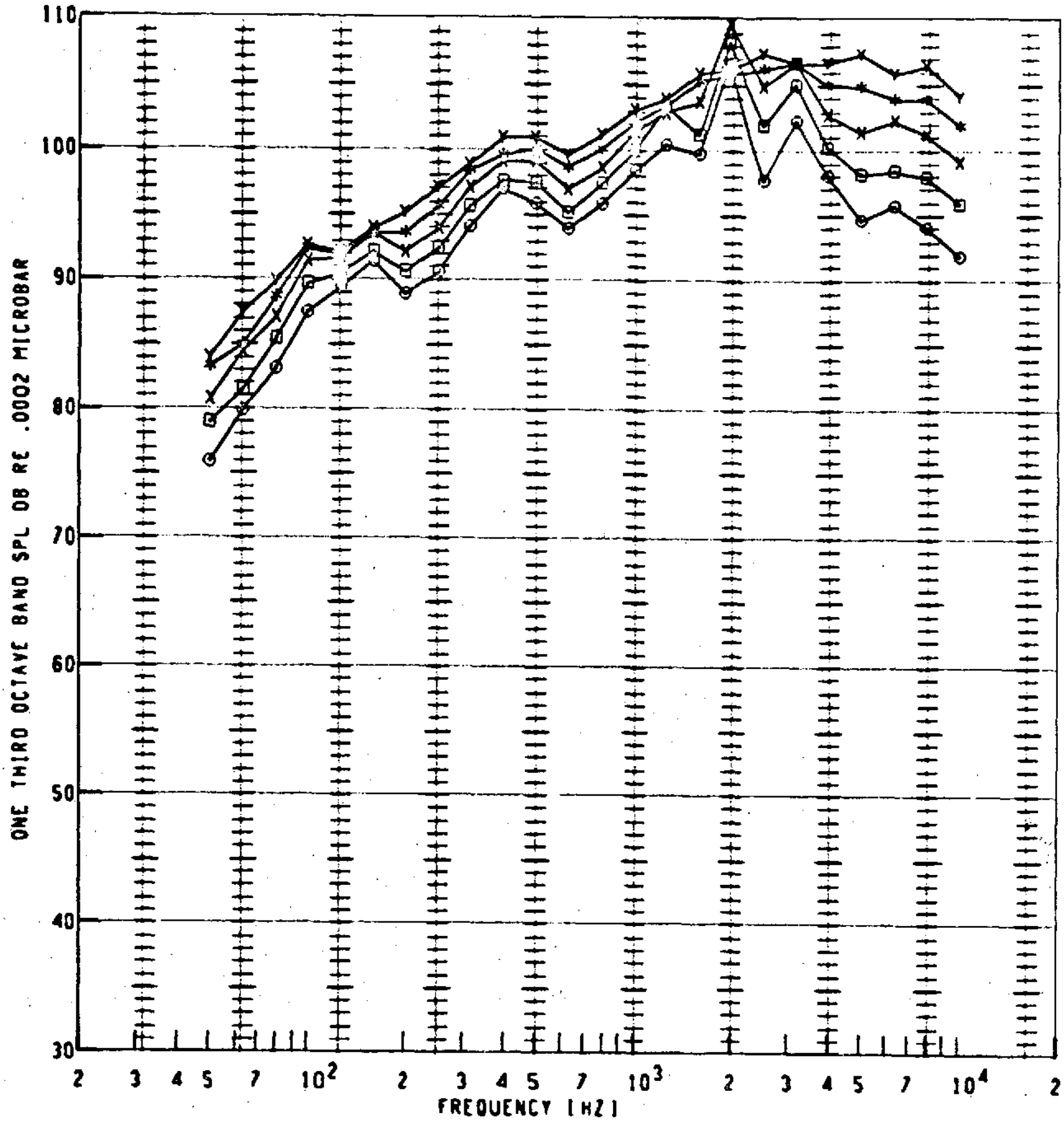
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	90G	50FP	111.0	10	750 F
⊡	6	-0	1.400	90G	50FP	113.5	10	800 F
X	6	-0	1.500	90G	50FP	115.0	0	850 F
*	6	-0	1.600	90G	50FP	114.8	0	900 F
Y	6	-0	1.700	90G	50FP	117.0	0	950 F

FIGURE 57.—BUFFALO NOZZLE JET NOISE SUPPRESSION

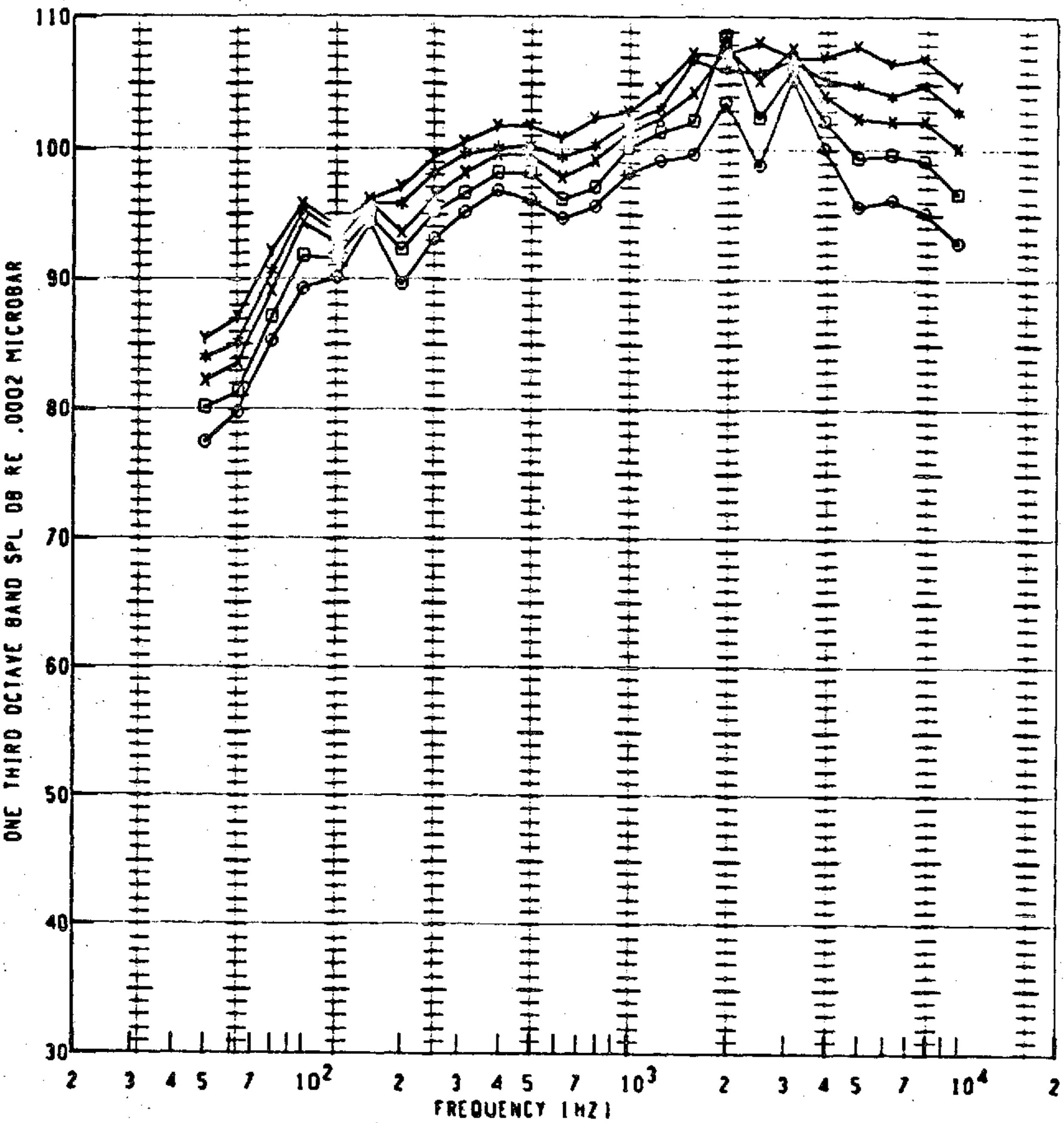
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	100G	50FP	111.4	10	750 F
⊡	6	-0	1.400	100G	50FP	113.9	10	800 F
X	6	-0	1.500	100G	50FP	115.9	0	850 F
*	6	-0	1.600	100G	50FP	116.1	0	900 F
Y	6	-0	1.700	100G	50FP	117.6	0	950 F

FIGURE 58.—BUFFALO NOZZLE JET NOISE SUPPRESSION

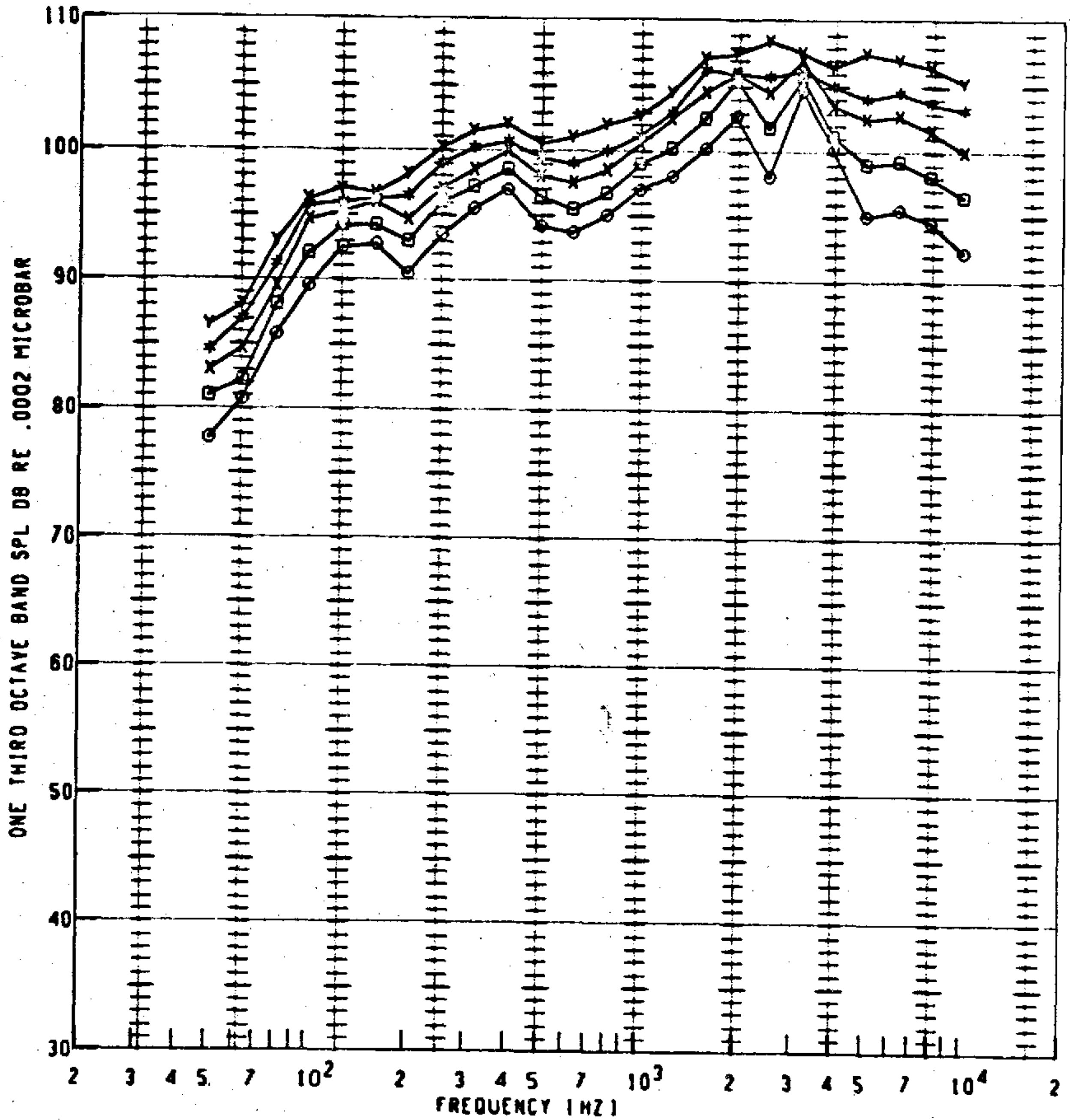
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	110G	50FP	111.6	10	750 F
⊡	6	-0	1.400	110G	50FP	114.6	10	800 F
X	6	-0	1.500	110G	50FP	115.6	10	850 F
*	6	-0	1.600	110G	50FP	116.6	0	900 F
Y	6	-0	1.700	110G	50FP	117.8	0	950 F

FIGURE 59.—BUFFALO NOZZLE JET NOISE SUPPRESSION

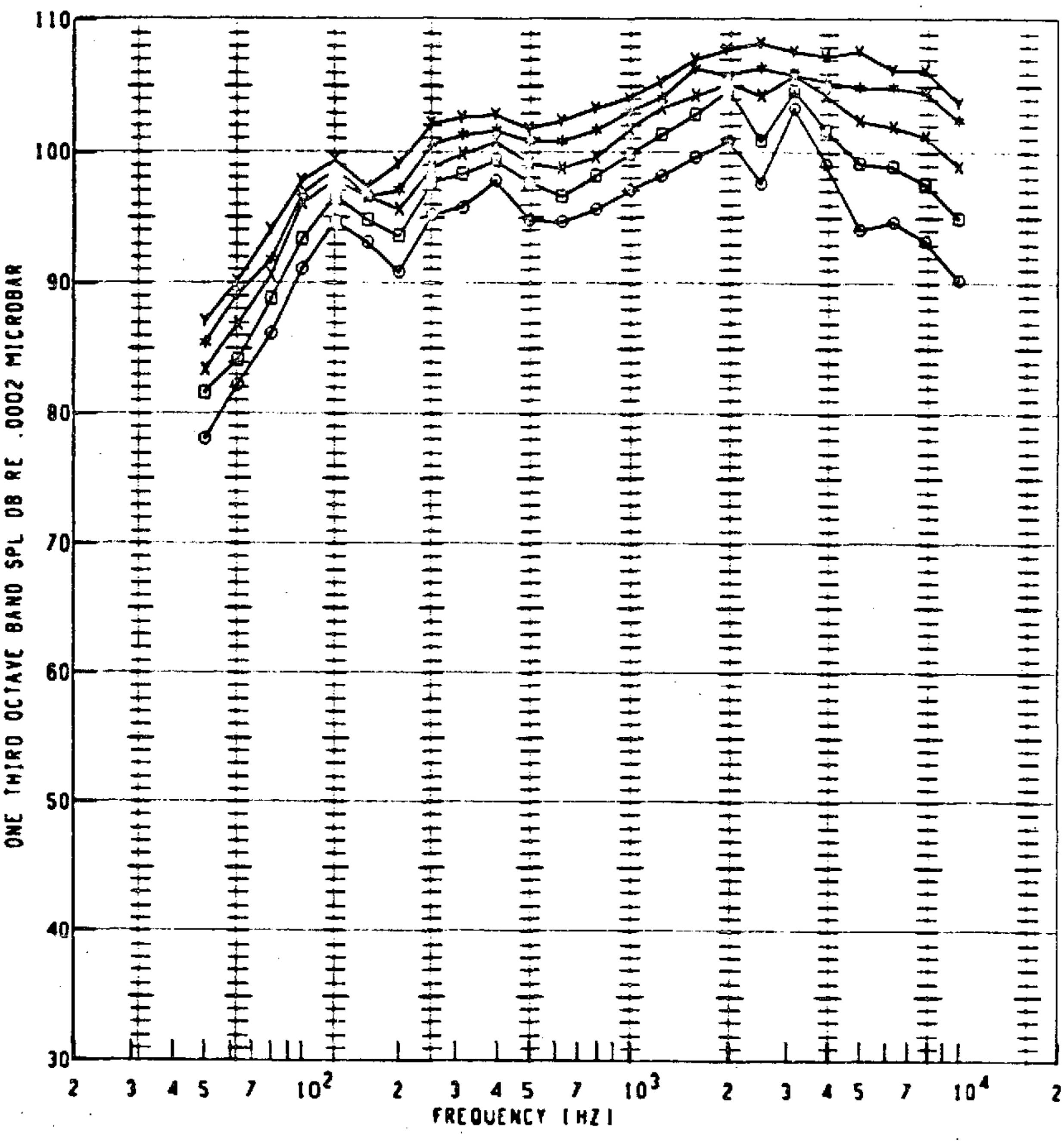
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	115G	50FP	111.2	10	750 F
⊡	6	-0	1.400	115G	50FP	113.2	10	800 F
X	6	-0	1.500	115G	50FP	114.7	10	850 F
*	6	-0	1.600	115G	50FP	116.2	0	900 F
Y	6	-0	1.700	115G	50FP	118.0	0	950 F

FIGURE 60.—BUFFALO NOZZLE JET NOISE SUPPRESSION

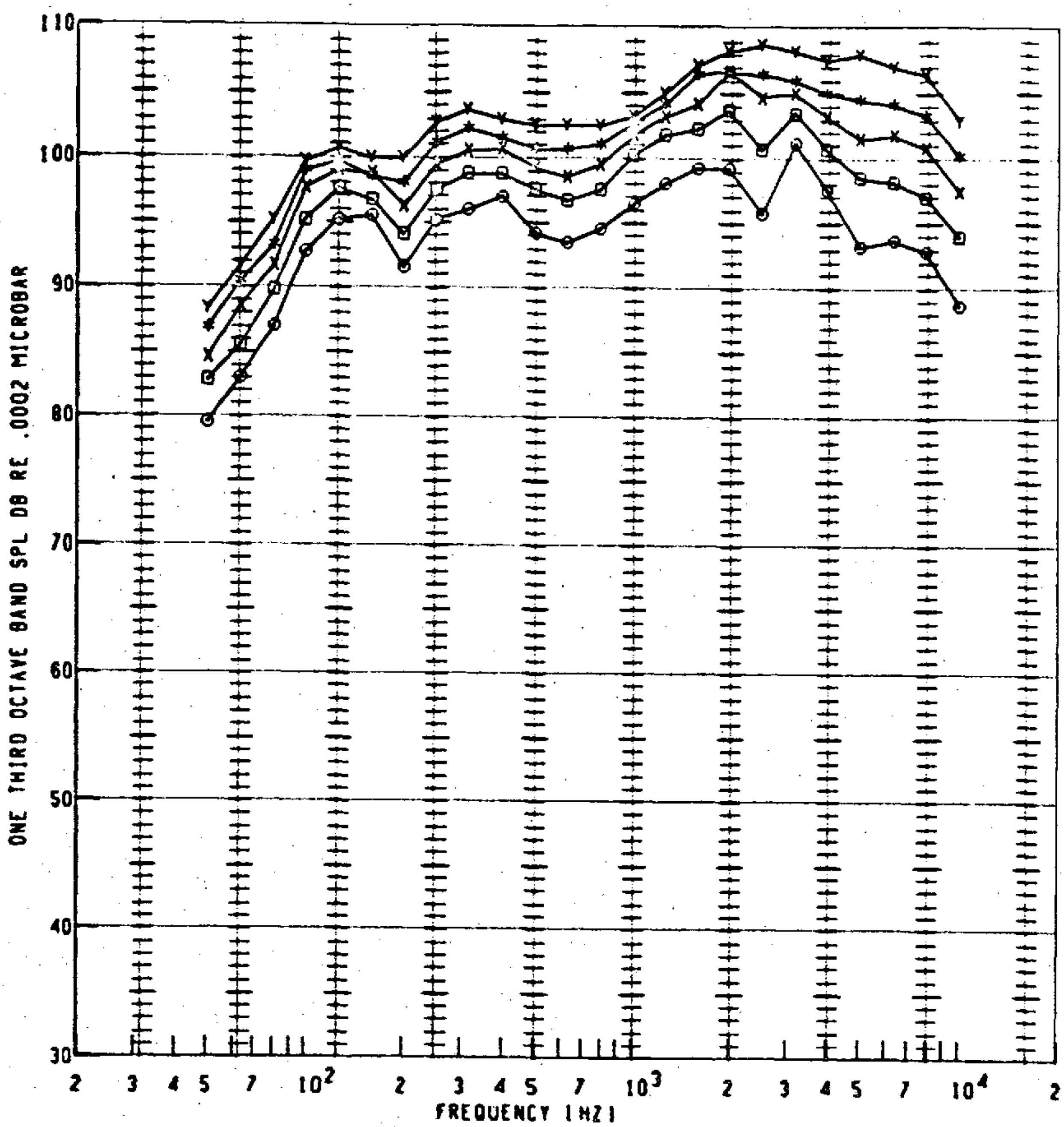
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	120G	50FP	110.6	10	750 F
⊡	6	-0	1.400	120G	50FP	113.6	10	800 F
X	6	-0	1.500	120G	50FP	114.8	10	850 F
*	6	-0	1.600	120G	50FP	116.6	0	900 F
Y	6	-0	1.700	120G	50FP	118.8	0	950 F

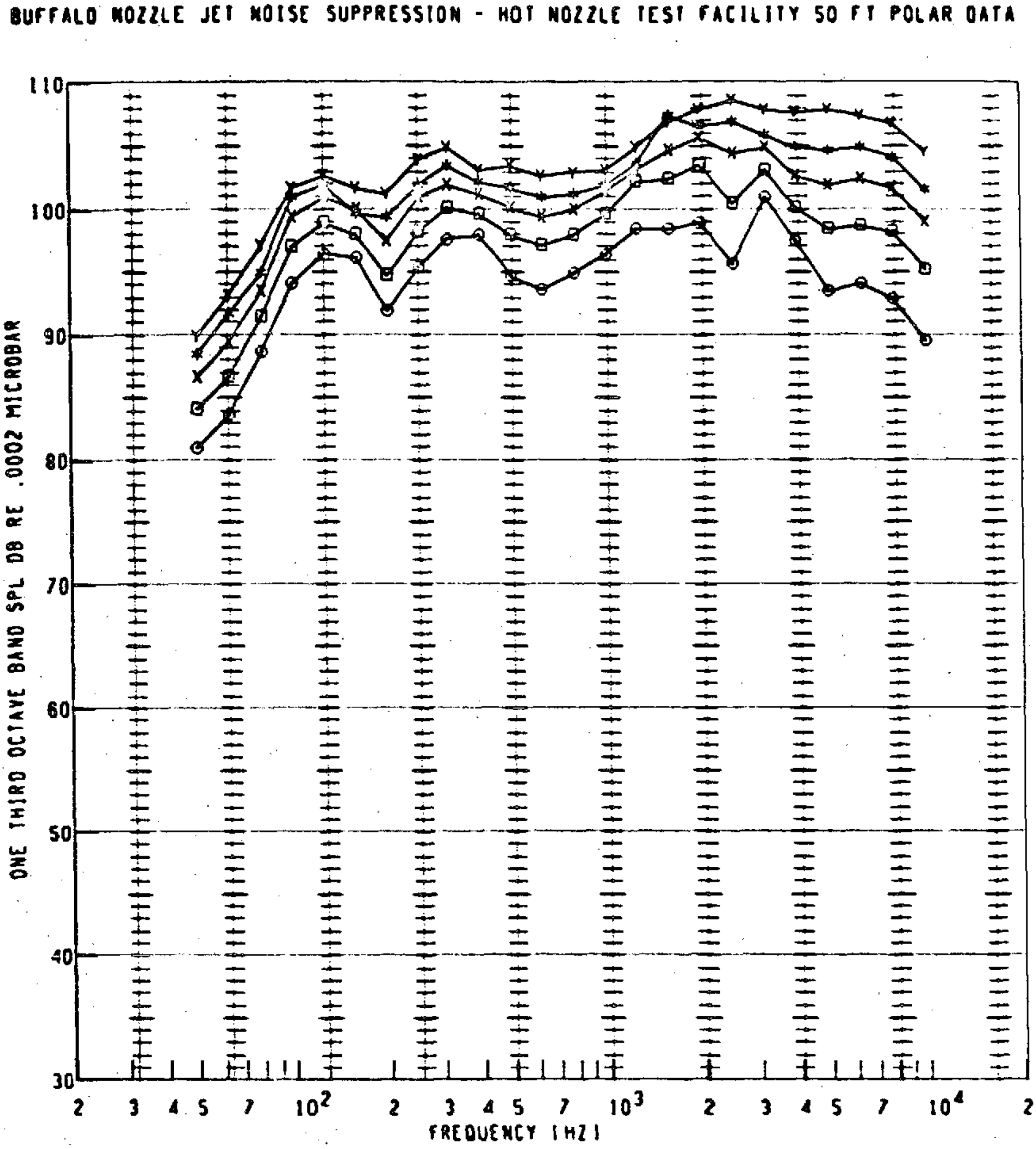
FIGURE 61.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	6	-0	1.300	125G	50FP	109.7	10	750 F
⊡	6	-0	1.400	125G	50FP	112.5	10	800 F
X	6	-0	1.500	125G	50FP	115.2	10	850 F
*	6	-0	1.600	125G	50FP	116.5	0	900 F
Y	6	-0	1.700	125G	50FP	118.5	0	950 F

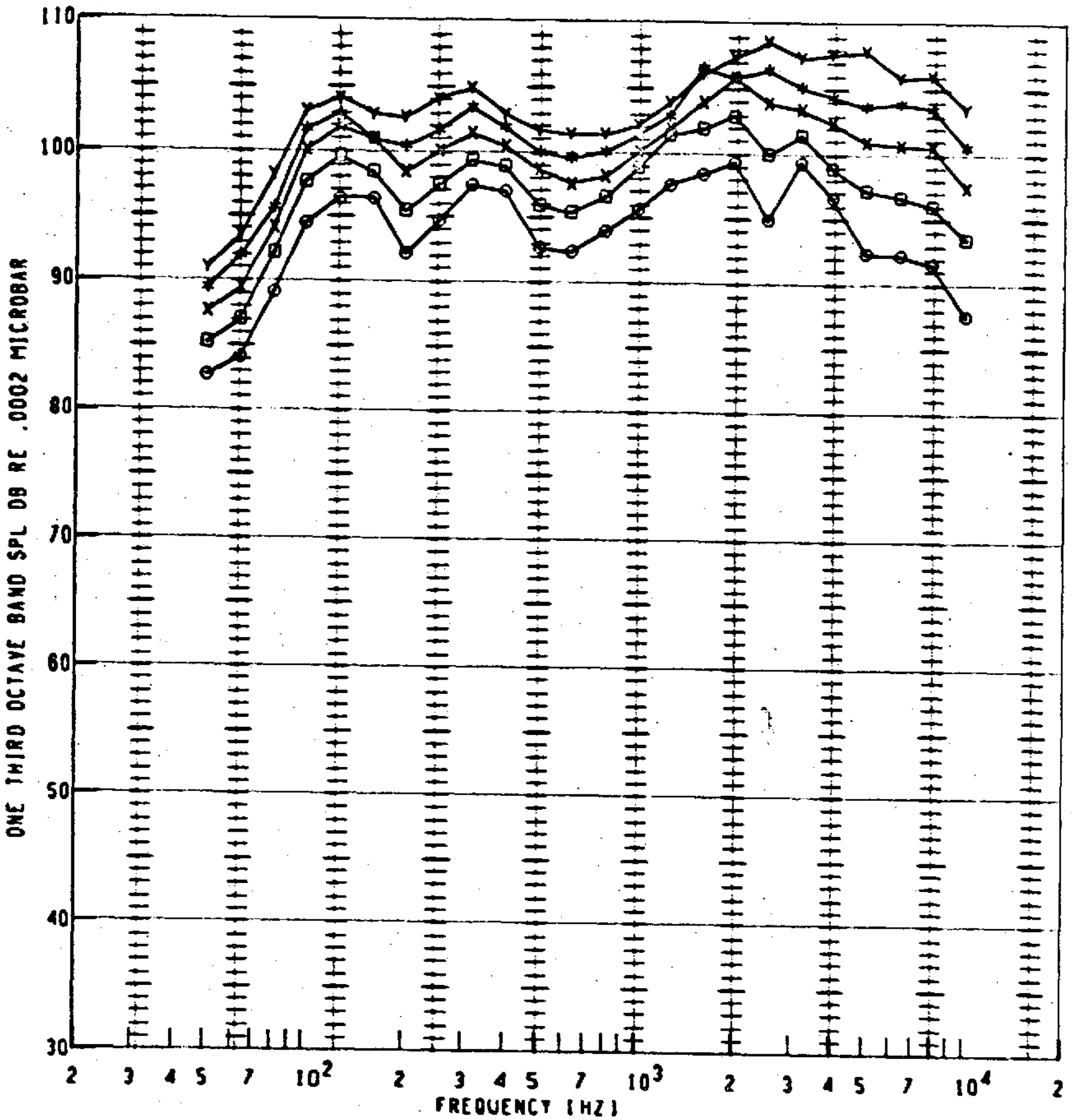
FIGURE 62.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	130G	50FP	109.9	10	750 F
⊡	6	-0	1.400	130G	50FP	113.1	10	800 F
X	6	-0	1.500	130G	50FP	115.4	10	850 F
*	6	-0	1.600	130G	50FP	116.9	0	900 F
Y	6	-0	1.700	130G	50FP	118.9	0	950 F

FIGURE 63.—BUFFALO NOZZLE JET NOISE SUPPRESSION

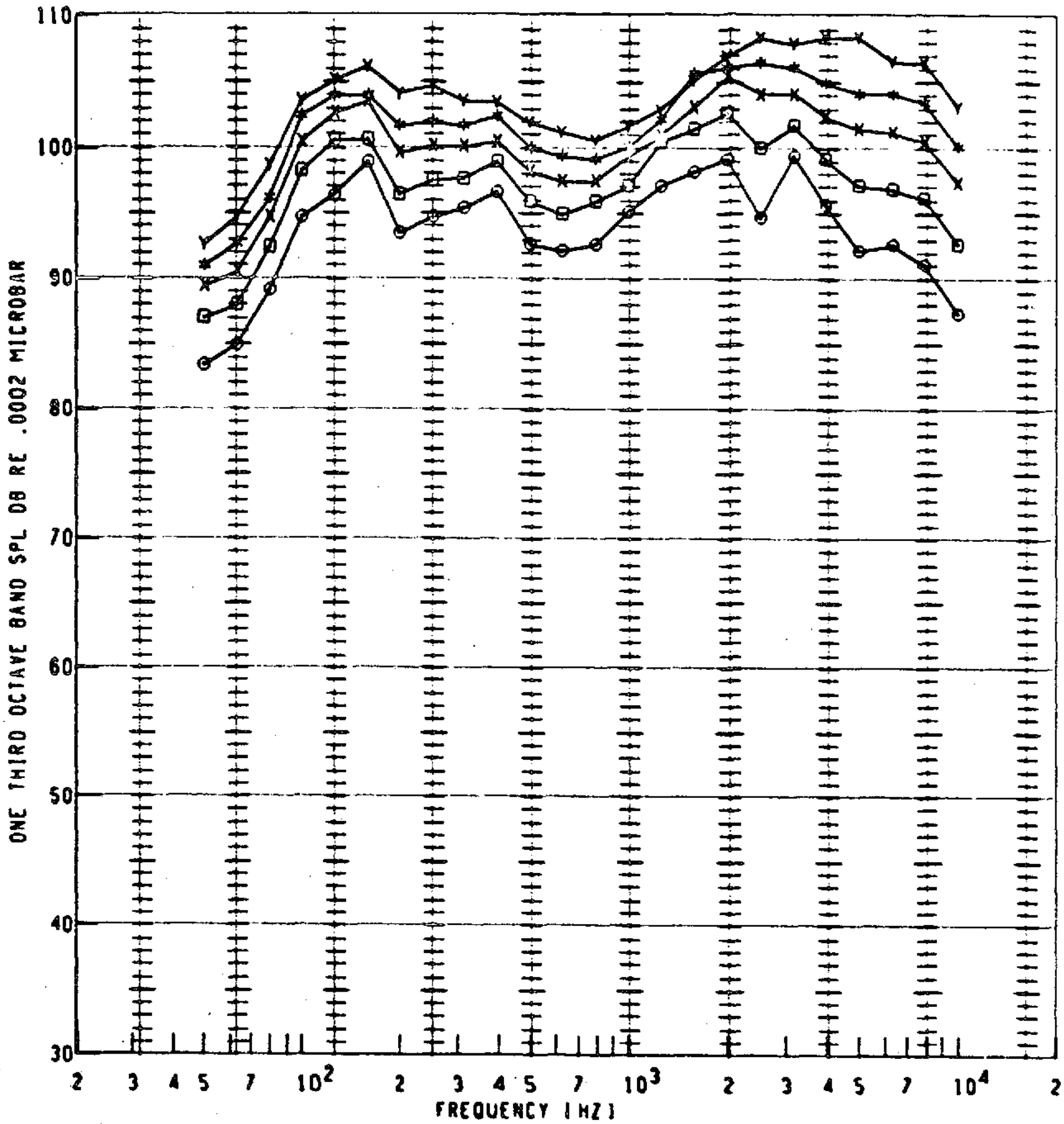
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	135G	50FP	109.1	10	750 F
⊡	6	-0	1.400	135G	50FP	112.4	10	800 F
X	6	-0	1.500	135G	50FP	114.9	10	850 F
*	6	-0	1.600	135G	50FP	116.6	0	900 F
Y	6	-0	1.700	135G	50FP	118.4	0	950 F

FIGURE 64.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	6	-0	1.300	140G	50FP	108.9	10	750 F
⊡	6	-0	1.400	140G	50FP	112.4	10	800 F
x	6	-0	1.500	140G	50FP	115.1	10	850 F
*	6	-0	1.600	140G	50FP	116.9	0	900 F
Y	6	-0	1.700	140G	50FP	118.9	0	950 F

FIGURE 65.—BUFFALO NOZZLE JET NOISE SUPPRESSION

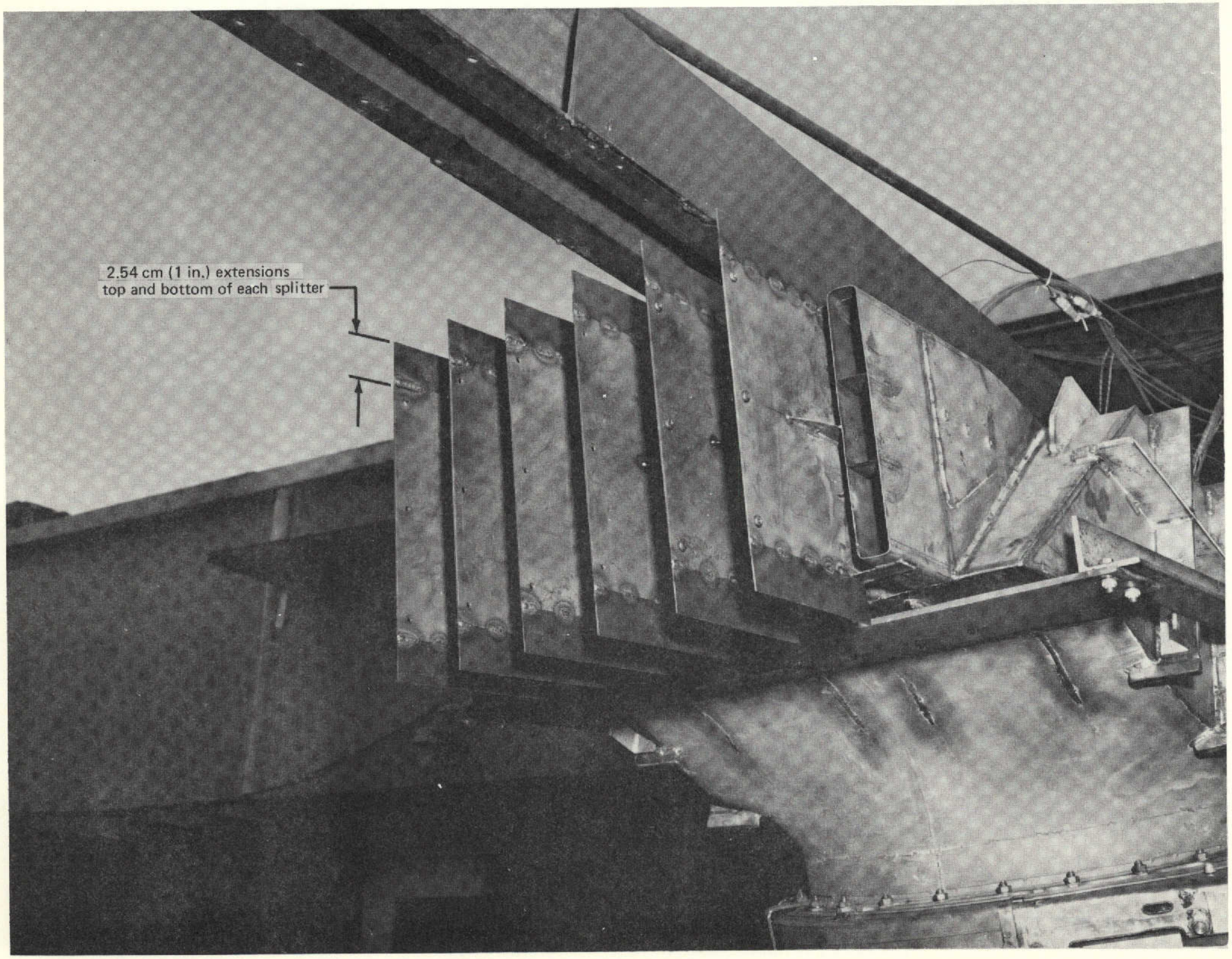


FIGURE 66.—2.54 cm (1 in.) EXTENSIONS ATTACHED TO UPPER AND LOWER EDGE OF EACH SPLITTER

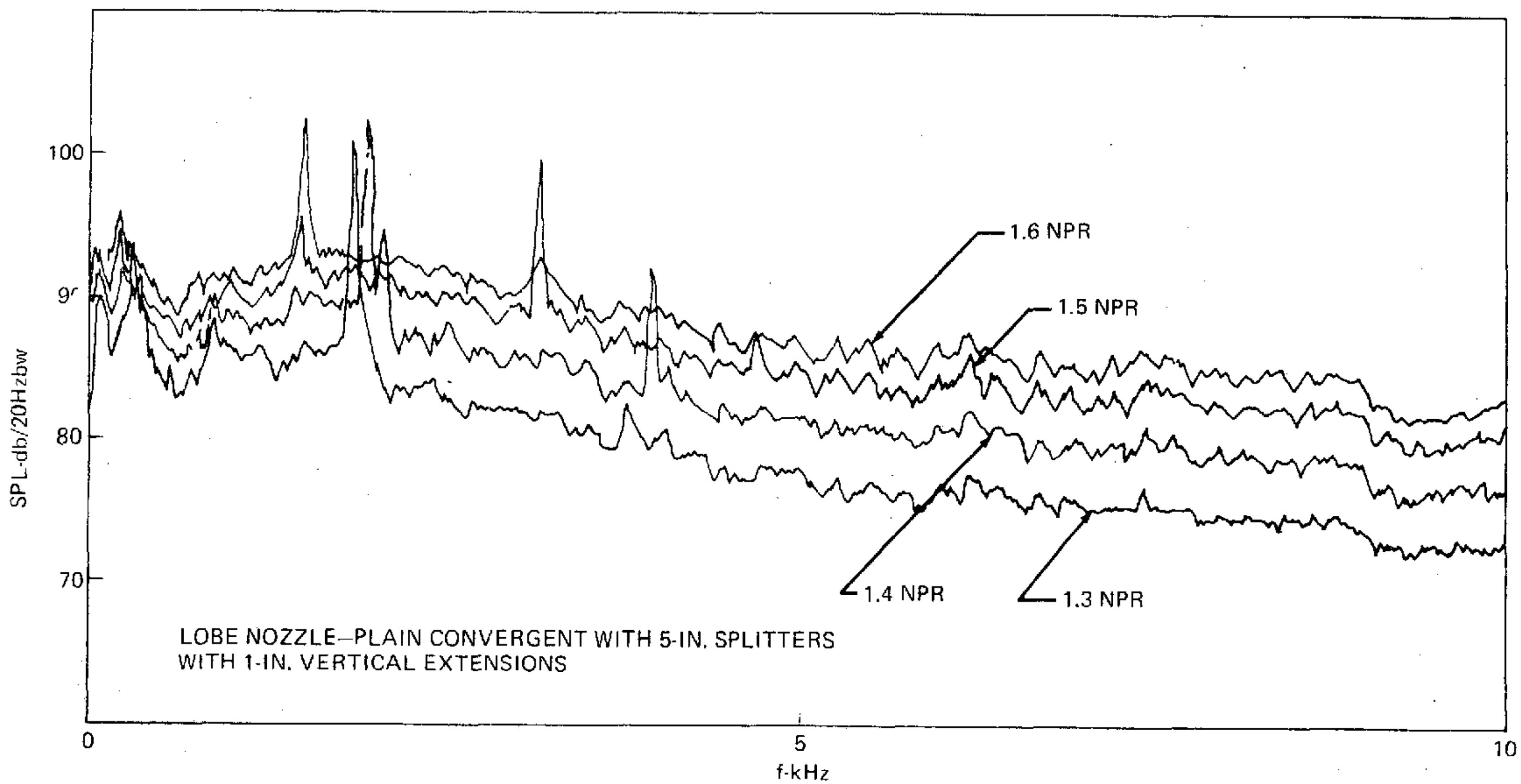
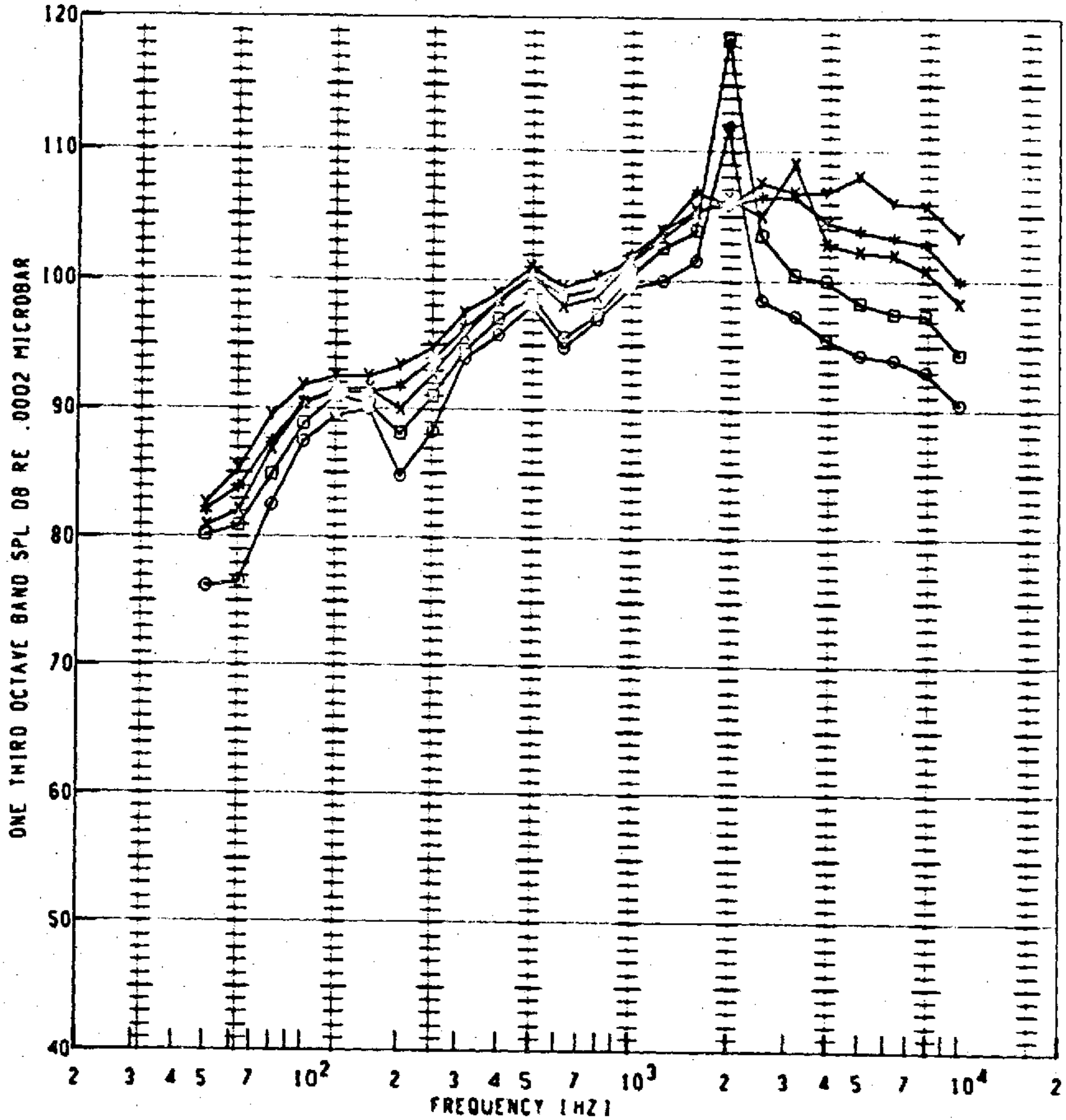


FIGURE 67.—NARROW-BAND ACOUSTICS OF RUN 8 AT 115° ANGLE

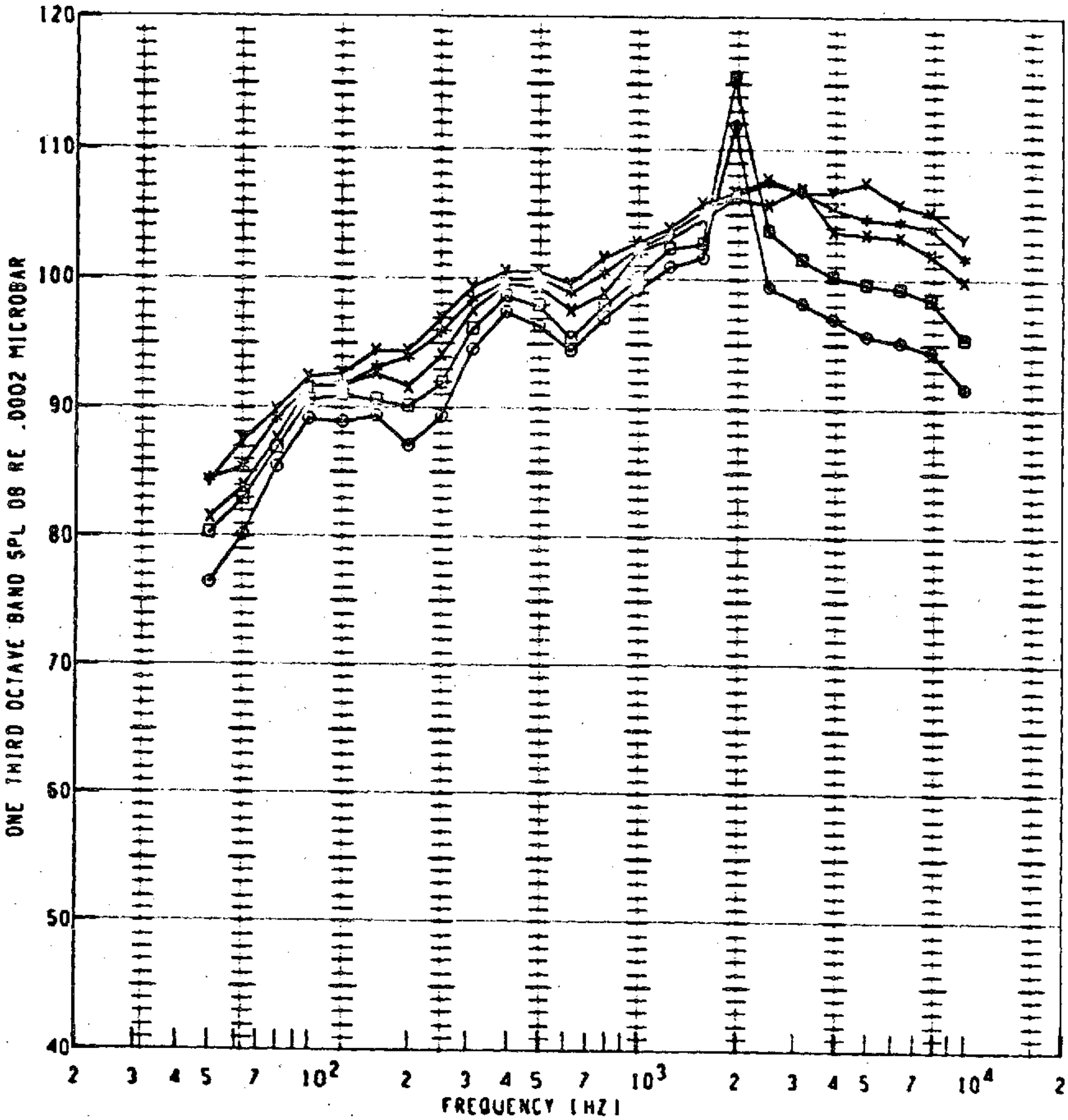
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	90G	50FP	113.8	10	750 F
⊡	8	-0	1.400	90G	50FP	119.3	0	800 F
X	8	-0	1.500	90G	50FP	115.5	10	850 F
*	8	-0	1.600	90G	50FP	116.0	0	900 F
Y	8	-0	1.700	90G	50FP	117.3	0	950 F

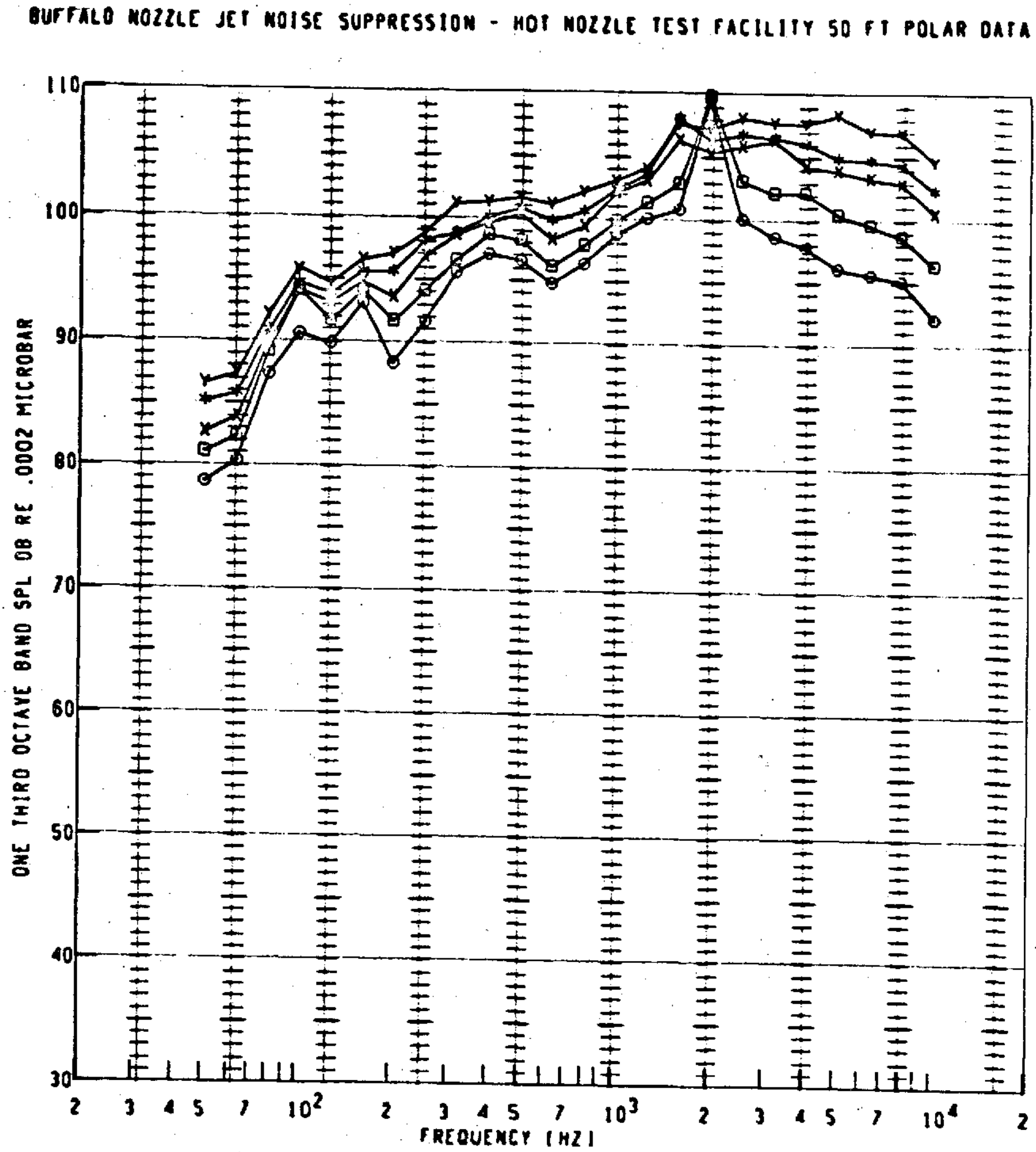
FIGURE 68.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	100G	50FP	113.9	10	750 F
⊡	8	-0	1.400	100G	50FP	117.1	10	800 F
X	8	-0	1.500	100G	50FP	115.6	10	850 F
*	8	-0	1.600	100G	50FP	117.1	10	900 F
Y	8	-0	1.700	100G	50FP	117.4	0	950 F

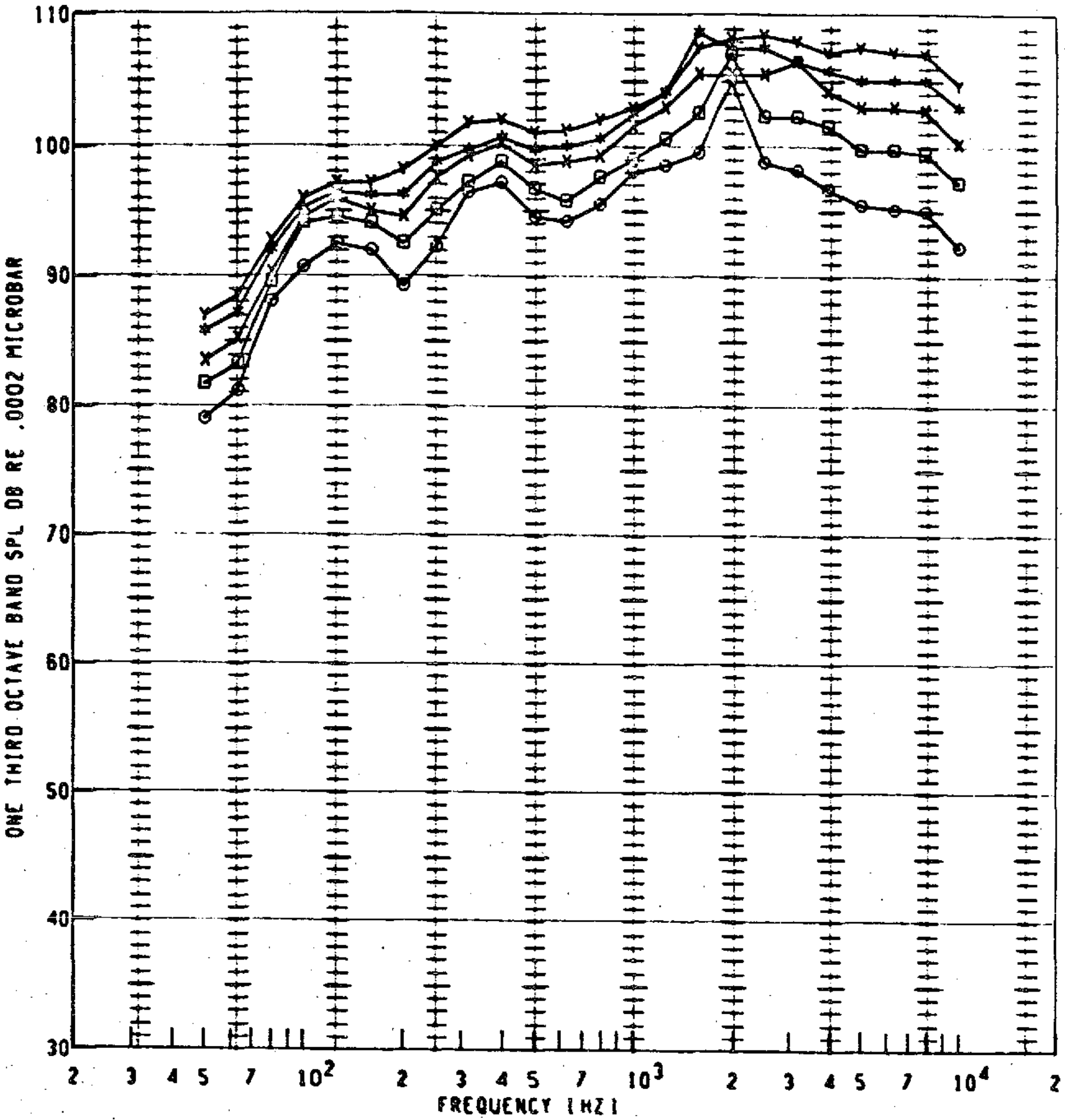
FIGURE 69.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	110G	50FP	112.6	10	750 F
⊡	8	-0	1.400	110G	50FP	114.3	10	800 F
X	8	-0	1.500	110G	50FP	115.6	10	850 F
*	8	-0	1.600	110G	50FP	117.1	10	900 F
Y	8	-0	1.700	110G	50FP	118.8	0	950 F

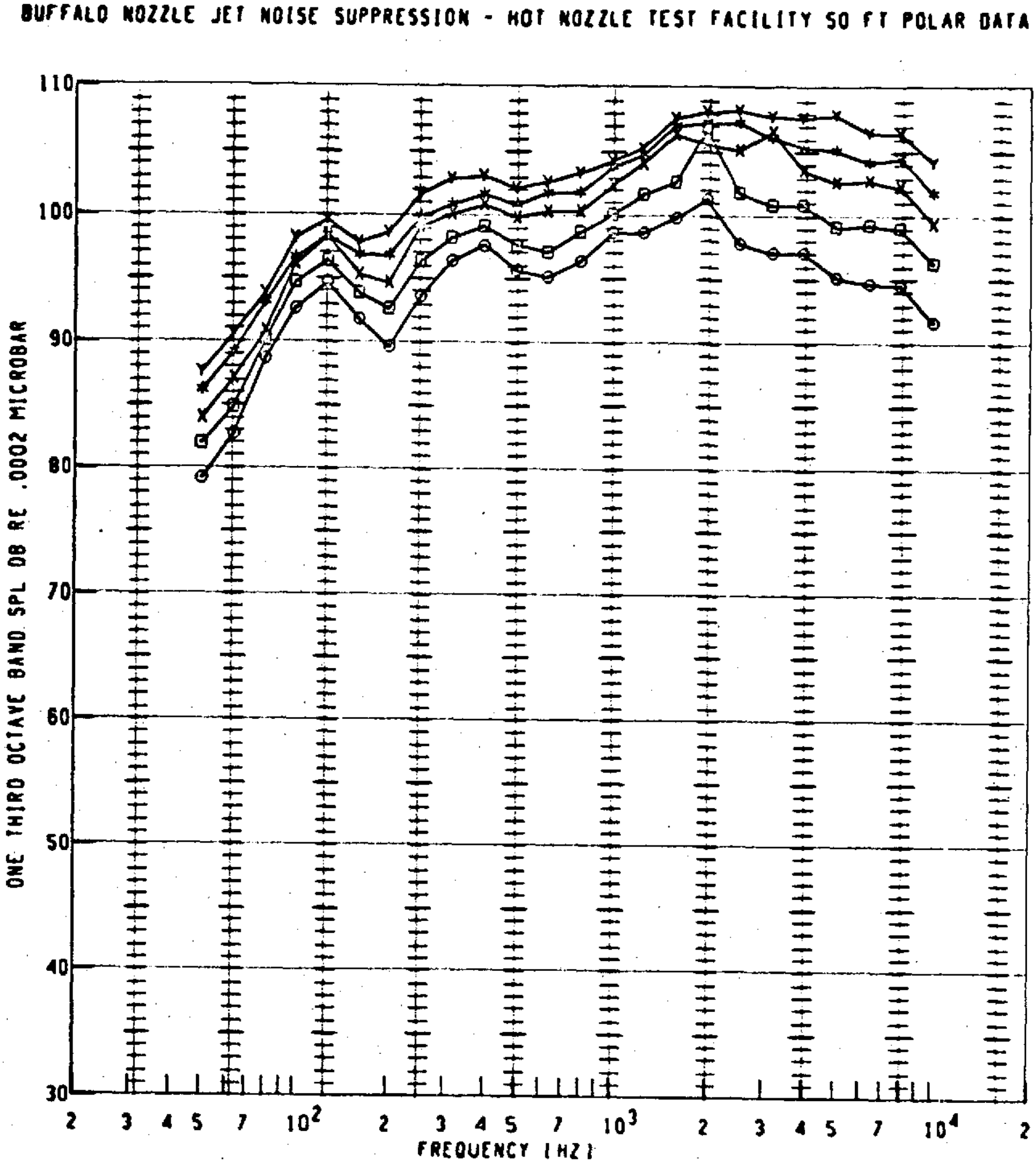
FIGURE 70.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



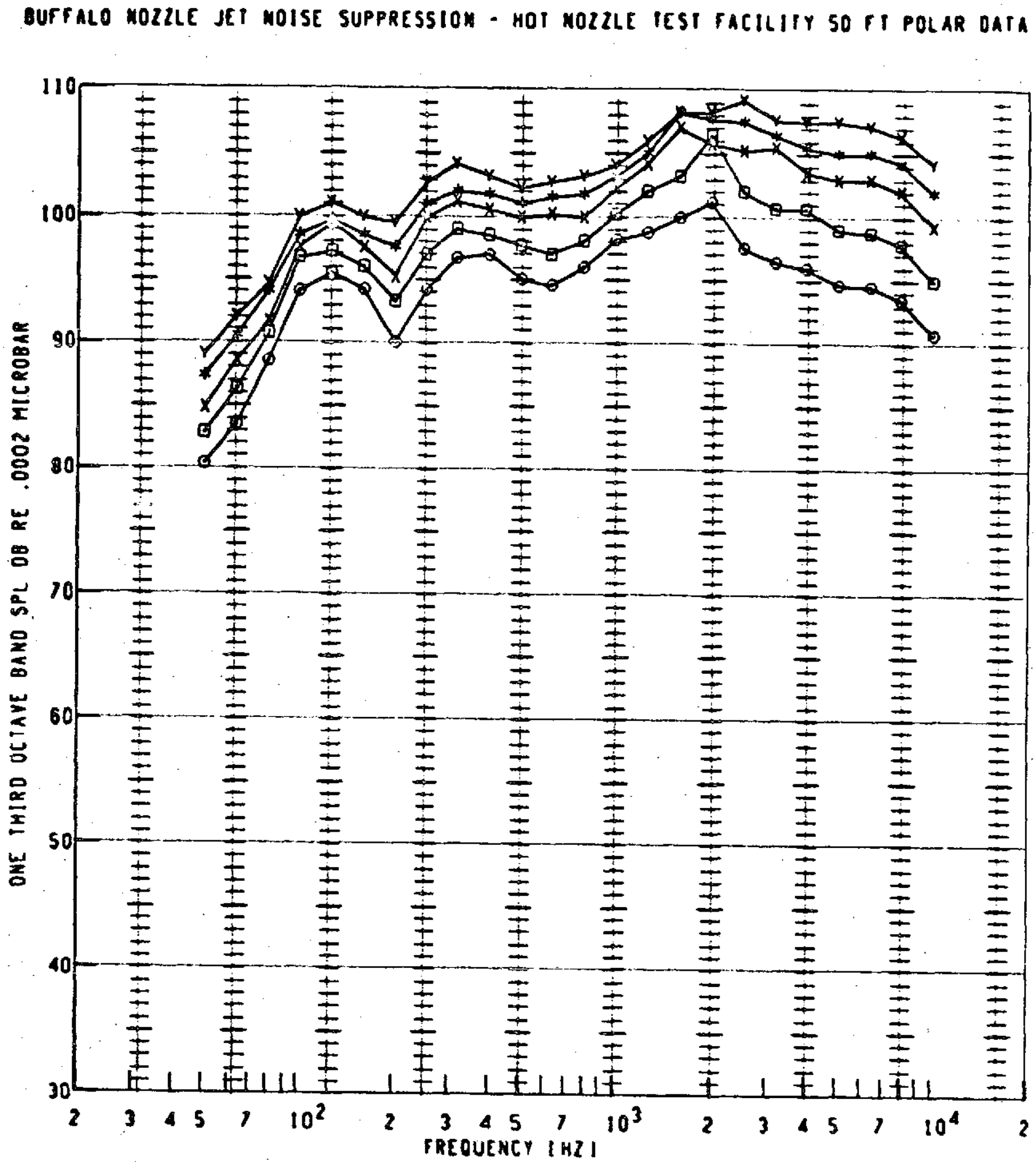
PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	115G	50FP	110.2	10	750 F
⊡	8	-0	1.400	115G	50FP	113.0	10	800 F
X	8	-0	1.500	115G	50FP	115.2	10	850 F
*	8	-0	1.600	115G	50FP	117.2	10	900 F
Y	8	-0	1.700	115G	50FP	118.0	0	950 F

FIGURE 71.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	120G	50FP	110.1	10	750 F
⊡	8	-0	1.400	120G	50FP	113.1	10	800 F
X	8	-0	1.500	120G	50FP	115.8	10	850 F
*	8	-0	1.600	120G	50FP	117.1	10	900 F
Y	8	-0	1.700	120G	50FP	118.6	0	950 F

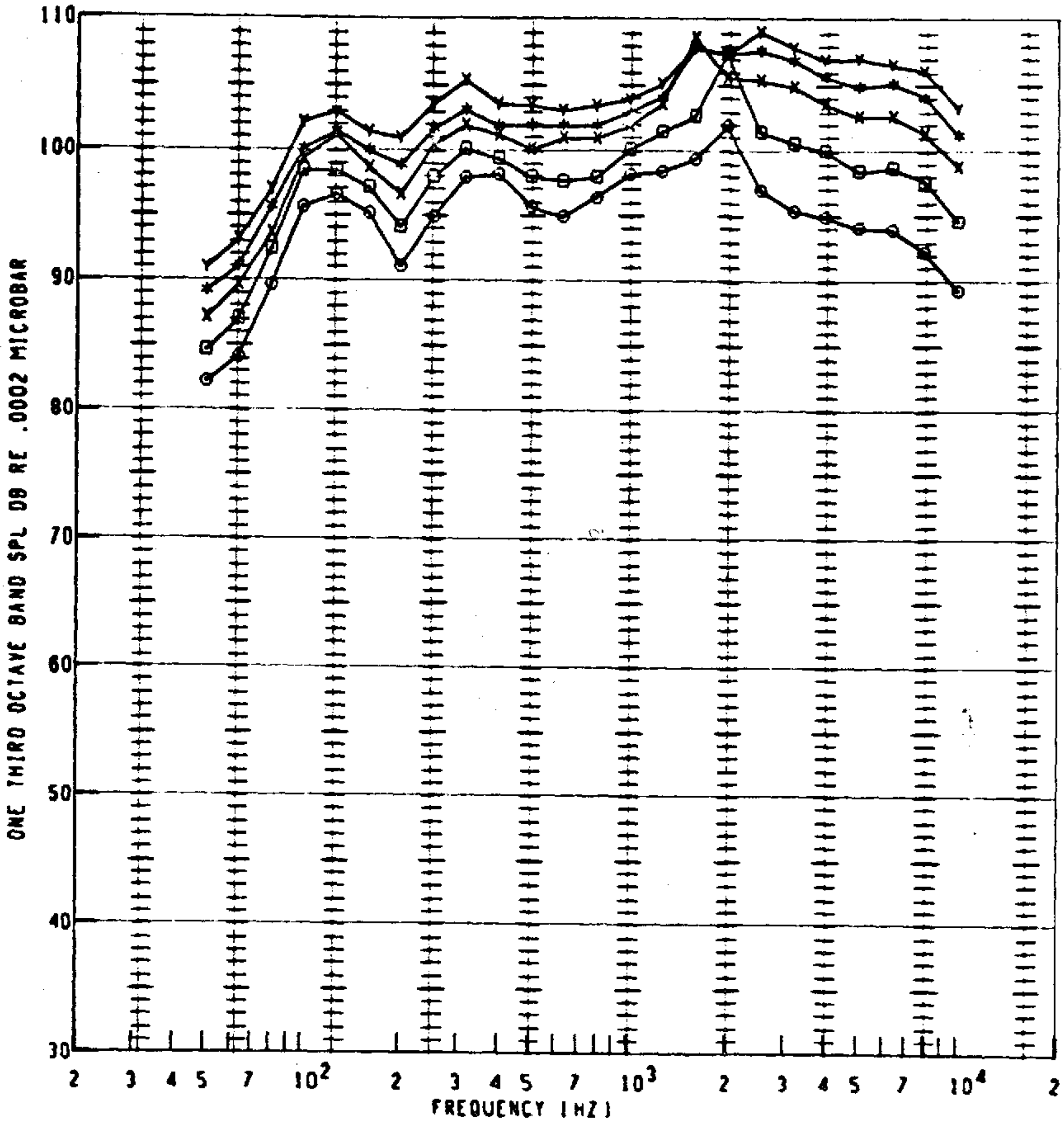
FIGURE 72.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	125G	50FP	109.7	10	750 F
⊡	8	-0	1.400	125G	50FP	113.0	10	800 F
X	8	-0	1.500	125G	50FP	115.7	10	850 F
*	8	-0	1.600	125G	50FP	118.0	10	900 F
Y	8	-0	1.700	125G	50FP	118.7	0	950 F

FIGURE 73.—BUFFALO NOZZLE JET NOISE SUPPRESSION

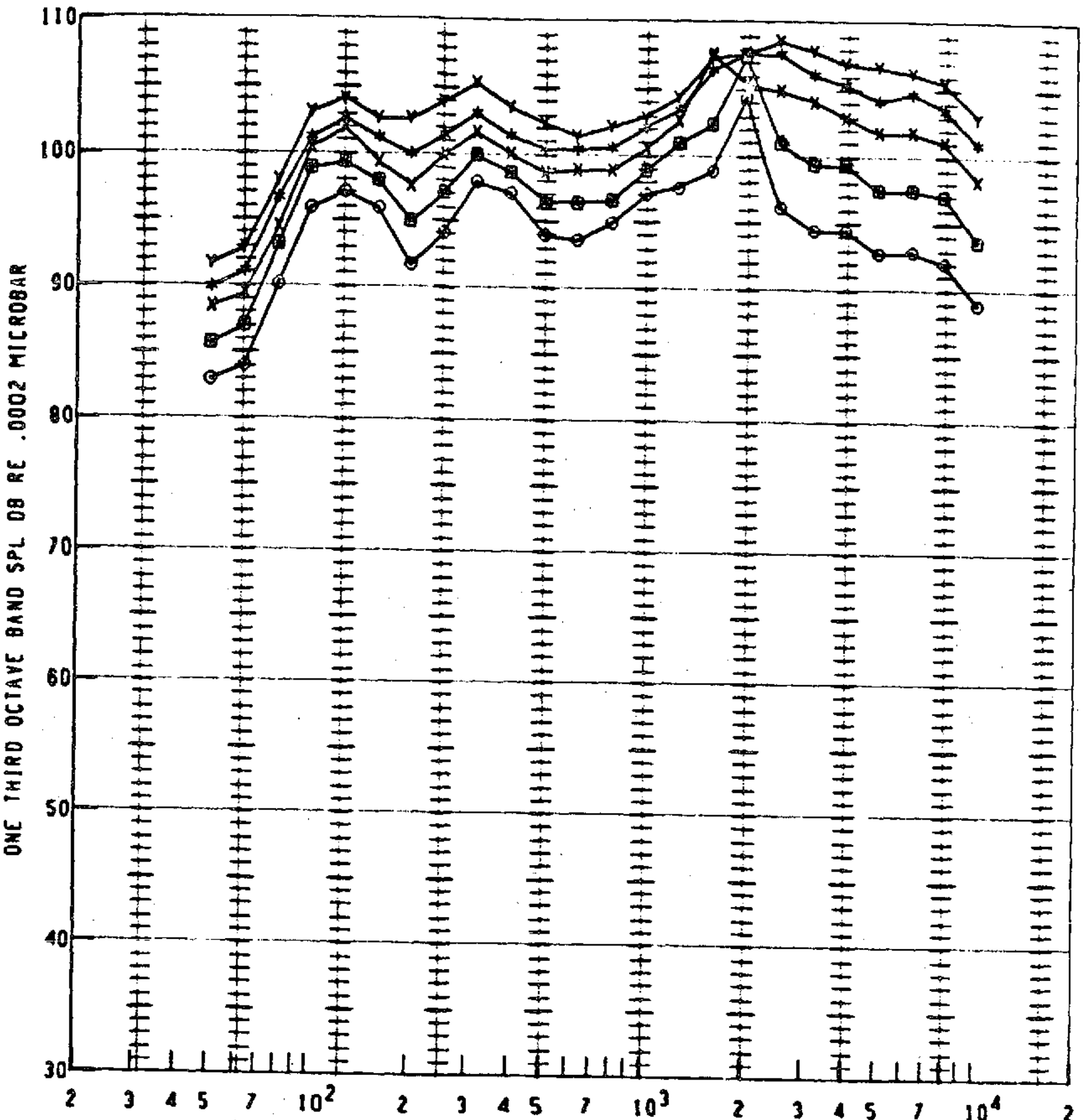
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	8	-0	1.300	130G	50FP	109.9	10	750 F
⊡	8	-0	1.400	130G	50FP	113.4	10	800 F
X	8	-0	1.500	130G	50FP	116.4	10	850 F
*	8	-0	1.600	130G	50FP	117.9	0	900 F
Y	8	-0	1.700	130G	50FP	118.9	0	950 F

FIGURE 74.—BUFFALO NOZZLE JET NOISE SUPPRESSION

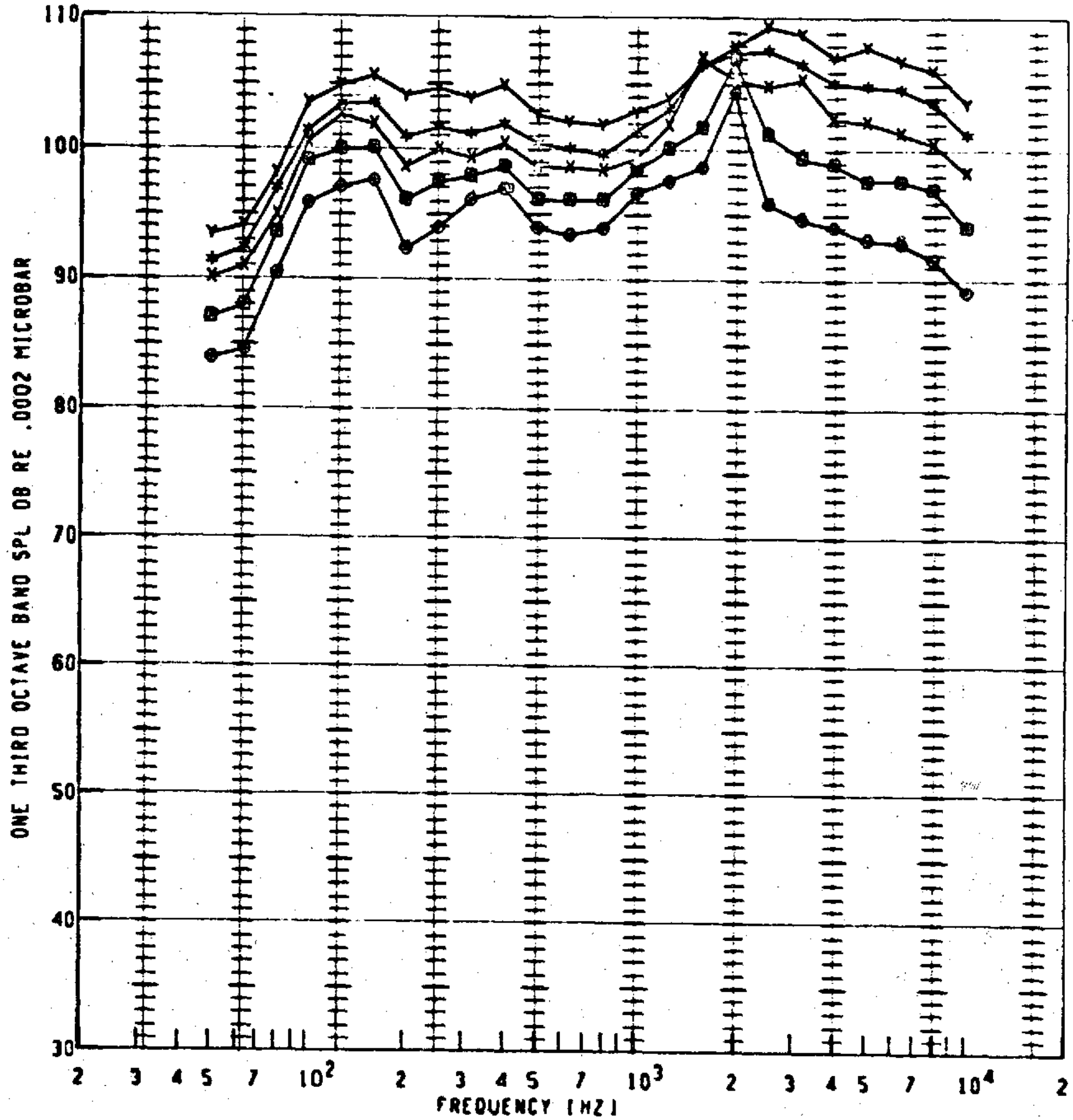
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	135G	50FP	109.6	10	750 F
⊡	8	-0	1.400	135G	50FP	112.6	10	800 F
X	8	-0	1.500	135G	50FP	115.9	10	850 F
*	8	-0	1.600	135G	50FP	117.4	0	900 F
Y	8	-0	1.700	135G	50FP	118.9	0	950 F

FIGURE 75.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	8	-0	1.300	140G	50FP	110.1	10	750 F
⊟	8	-0	1.400	140G	50FP	113.1	10	800 F
X	8	-0	1.500	140G	50FP	115.6	10	850 F
*	8	-0	1.600	140G	50FP	117.6	0	900 F
Y	8	-0	1.700	140G	50FP	119.1	0	950 F

FIGURE 76.—BUFFALO NOZZLE JET NOISE SUPPRESSION

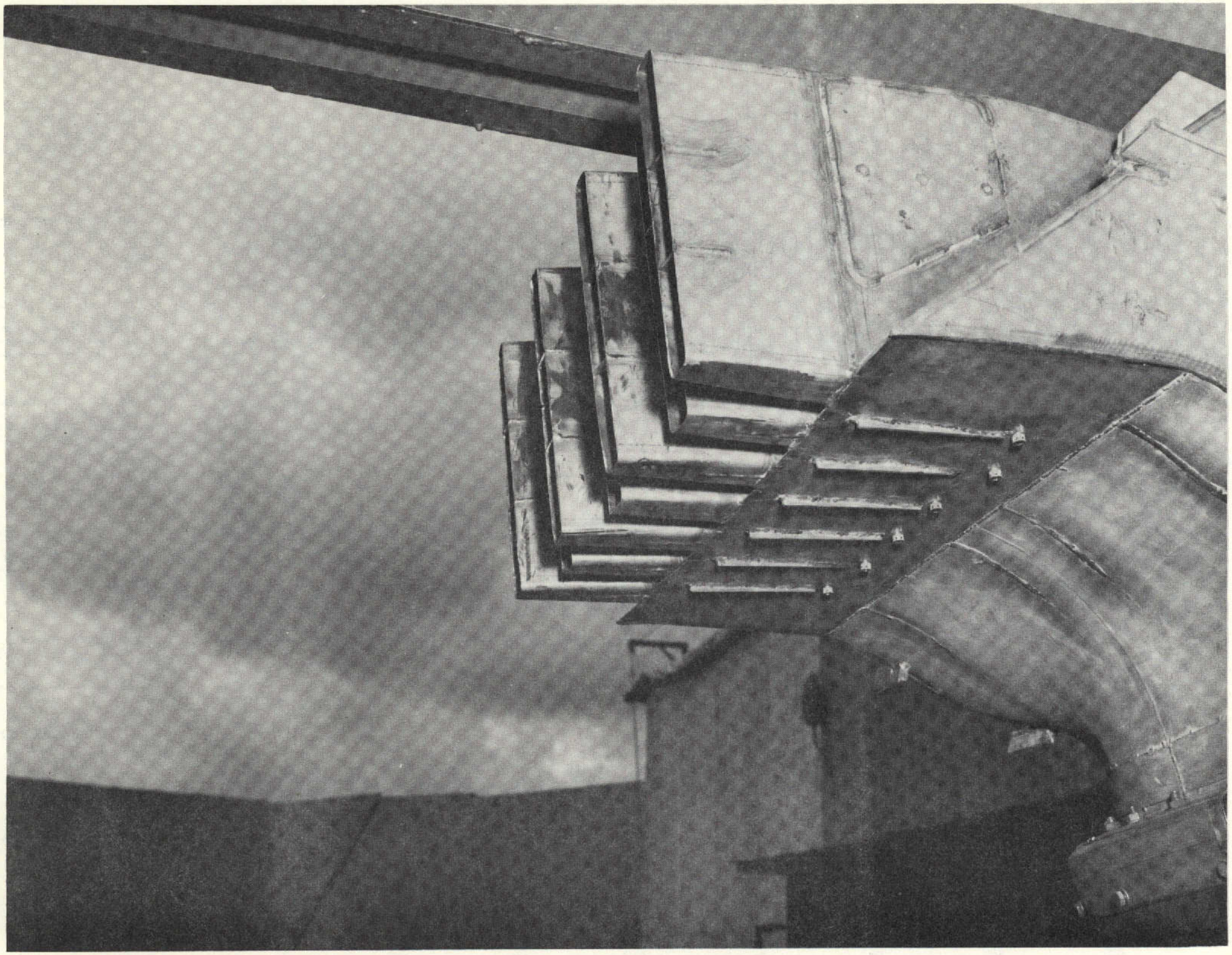


FIGURE 77.—BNS-3 PLAIN LOBE NOZZLE WITH 2.54 cm (1-in.) REMOVED FROM ALTERNATE LOBES

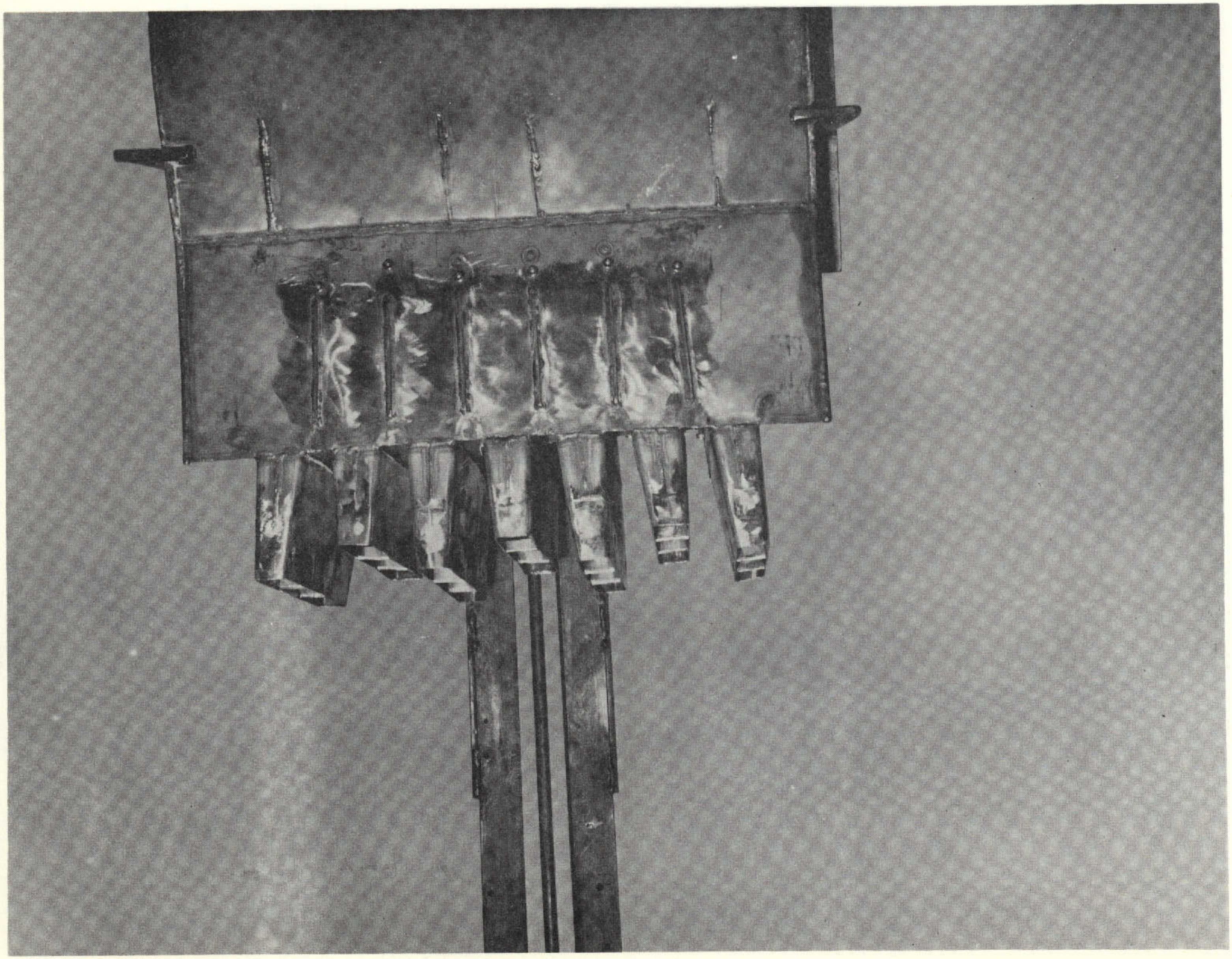


FIGURE 78.—BNS-3 NOZZLE WITH 2.54 cm (1-in.) REMOVED FROM ALTERNATE LOBES

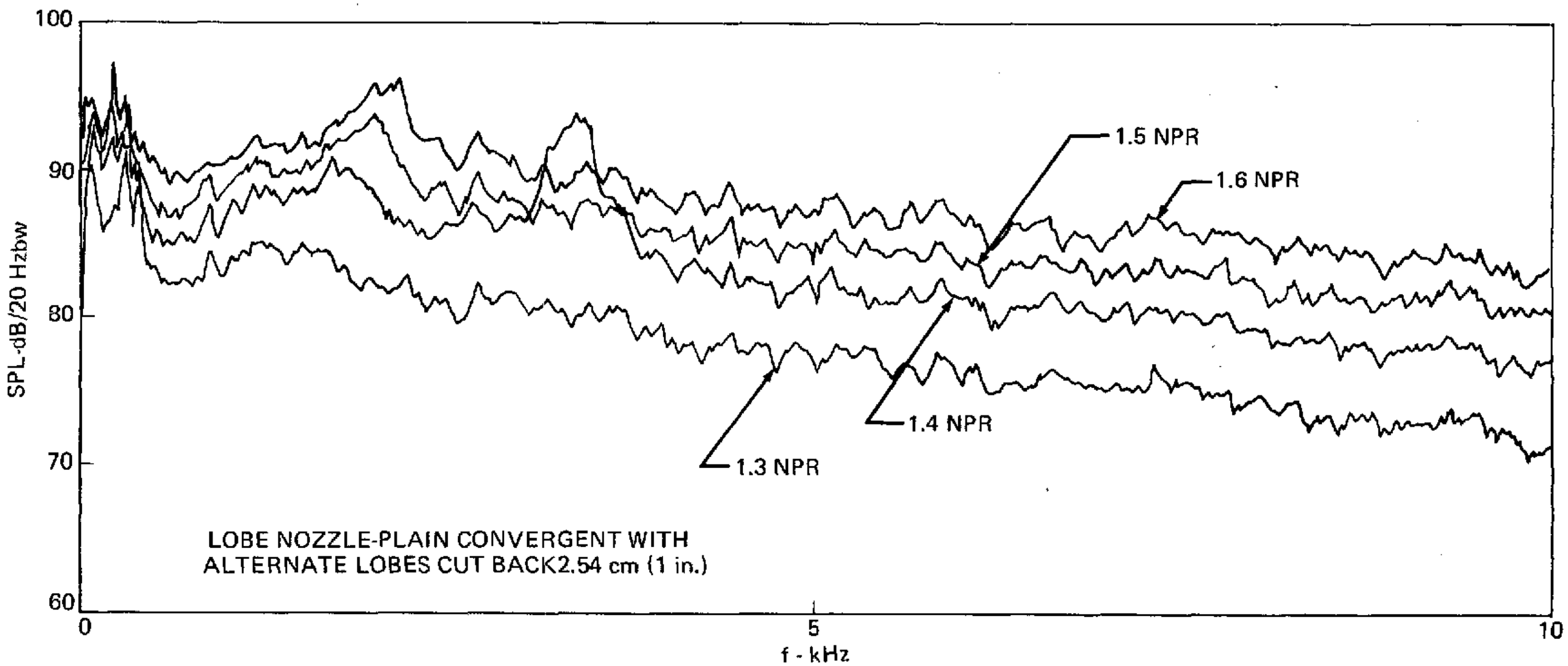
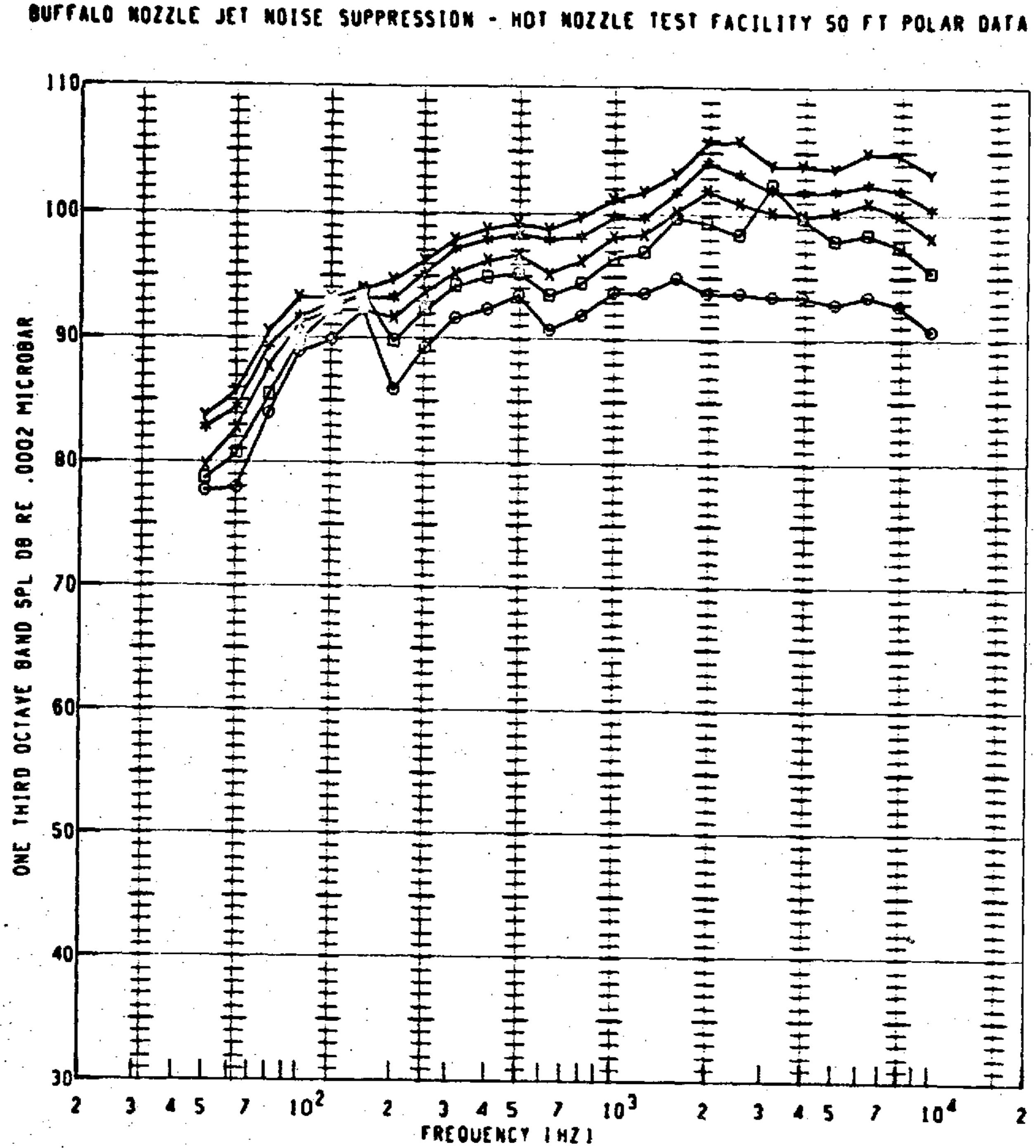


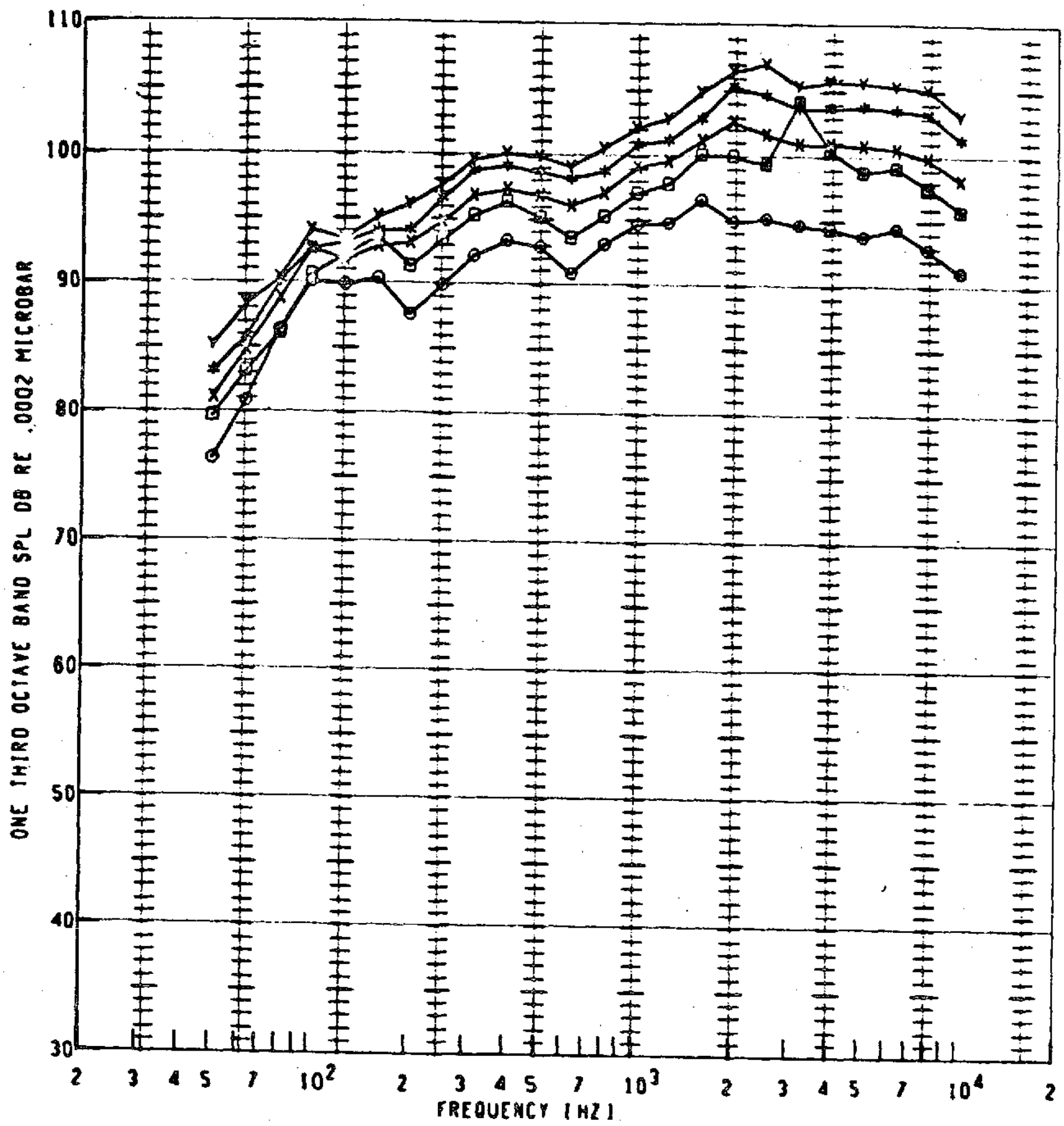
FIGURE 79.—NARROW-BAND ACOUSTICS OF RUN 9 AT 115° ANGLE



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	9	-0	1.300	90G	50FP	105.9	20	750 F
⊡	9	-0	1.400	90G	50FP	110.2	10	800 F
X	9	-0	1.500	90G	50FP	111.7	10	850 F
*	9	-0	1.600	90G	50FP	113.7	10	900 F
Y	9	-0	1.700	90G	50FP	115.7	10	950 F

FIGURE 80.—BUFFALO NOZZLE JET NOISE SUPPRESSION

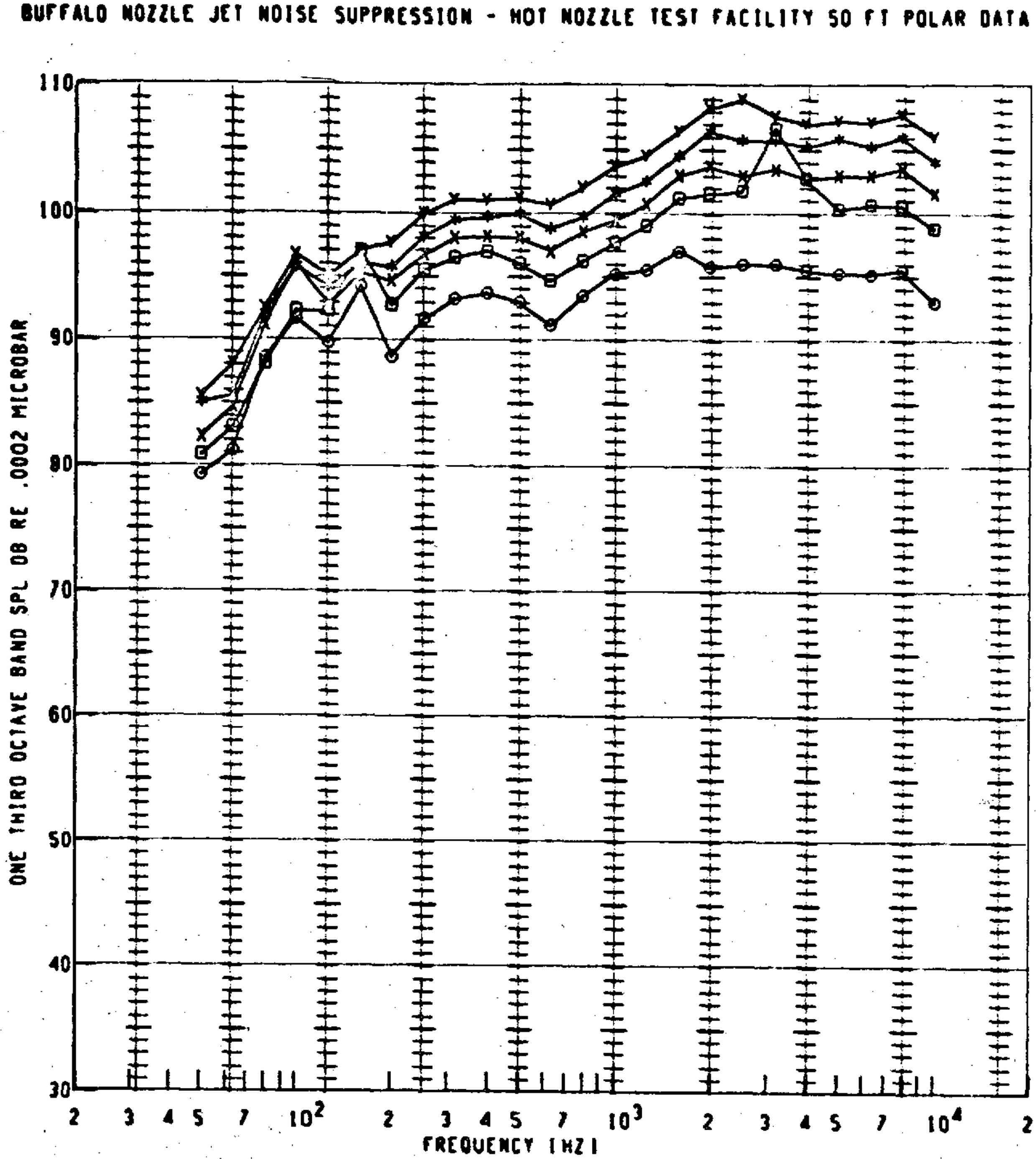
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	9	-0	1.300	100G	50FP	107.1	20	750 F
⊡	9	-0	1.400	100G	50FP	111.8	10	800 F
X	9	-0	1.500	100G	50FP	112.8	10	850 F
*	9	-0	1.600	100G	50FP	115.3	10	900 F
Y	9	-0	1.700	100G	50FP	116.8	10	950 F

FIGURE 81.—BUFFALO NOZZLE JET NOISE SUPPRESSION

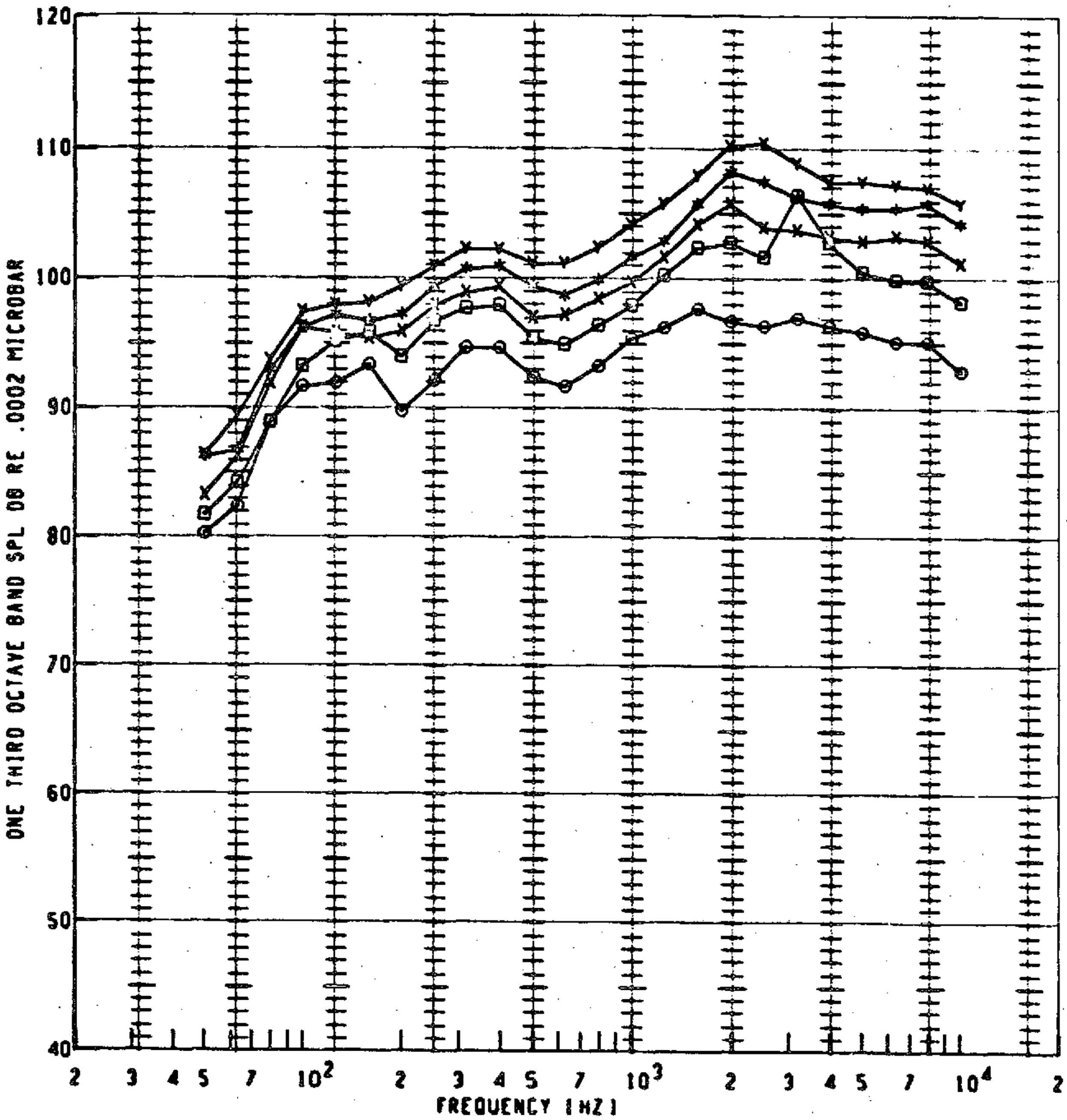
C-2



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	9	-0	1.300	110G	50FP	107.5	20	750 F
⊡	9	-0	1.400	110G	50FP	113.5	10	800 F
X	9	-0	1.500	110G	50FP	114.5	10	850 F
*	9	-0	1.600	110G	50FP	116.7	10	900 F
Y	9	-0	1.700	110G	50FP	118.5	10	950 F

FIGURE 82.—BUFFALO NOZZLE JET NOISE SUPPRESSION

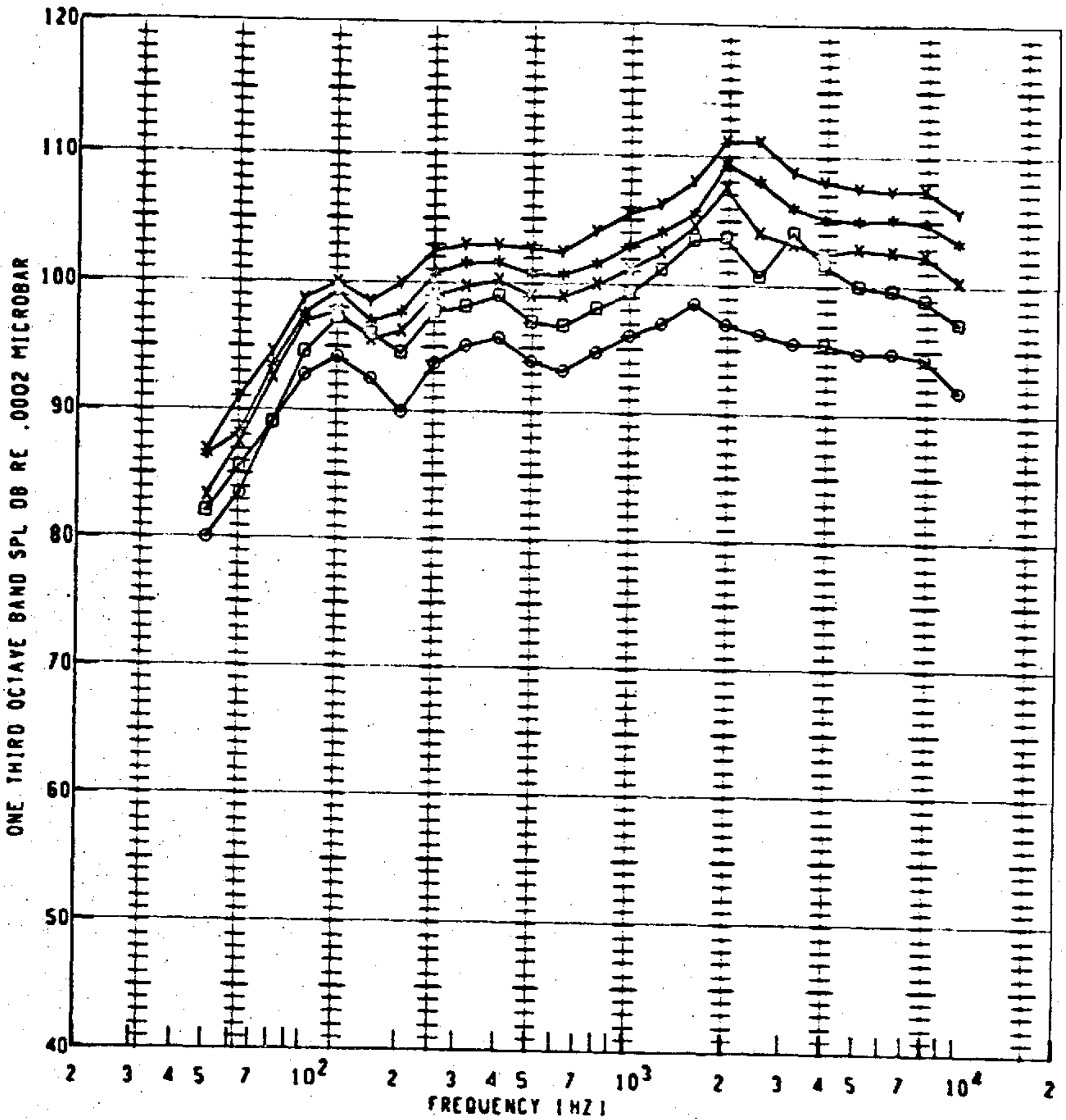
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	9	-0	1.300	115G	50FP	108.2	20	750 F
⊟	9	-0	1.400	115G	50FP	113.4	10	800 F
X	9	-0	1.500	115G	50FP	114.9	10	850 F
*	9	-0	1.600	115G	50FP	116.9	10	900 F
Y	9	-0	1.700	115G	50FP	119.4	0	950 F

FIGURE 83.—BUFFALO NOZZLE JET NOISE SUPPRESSION

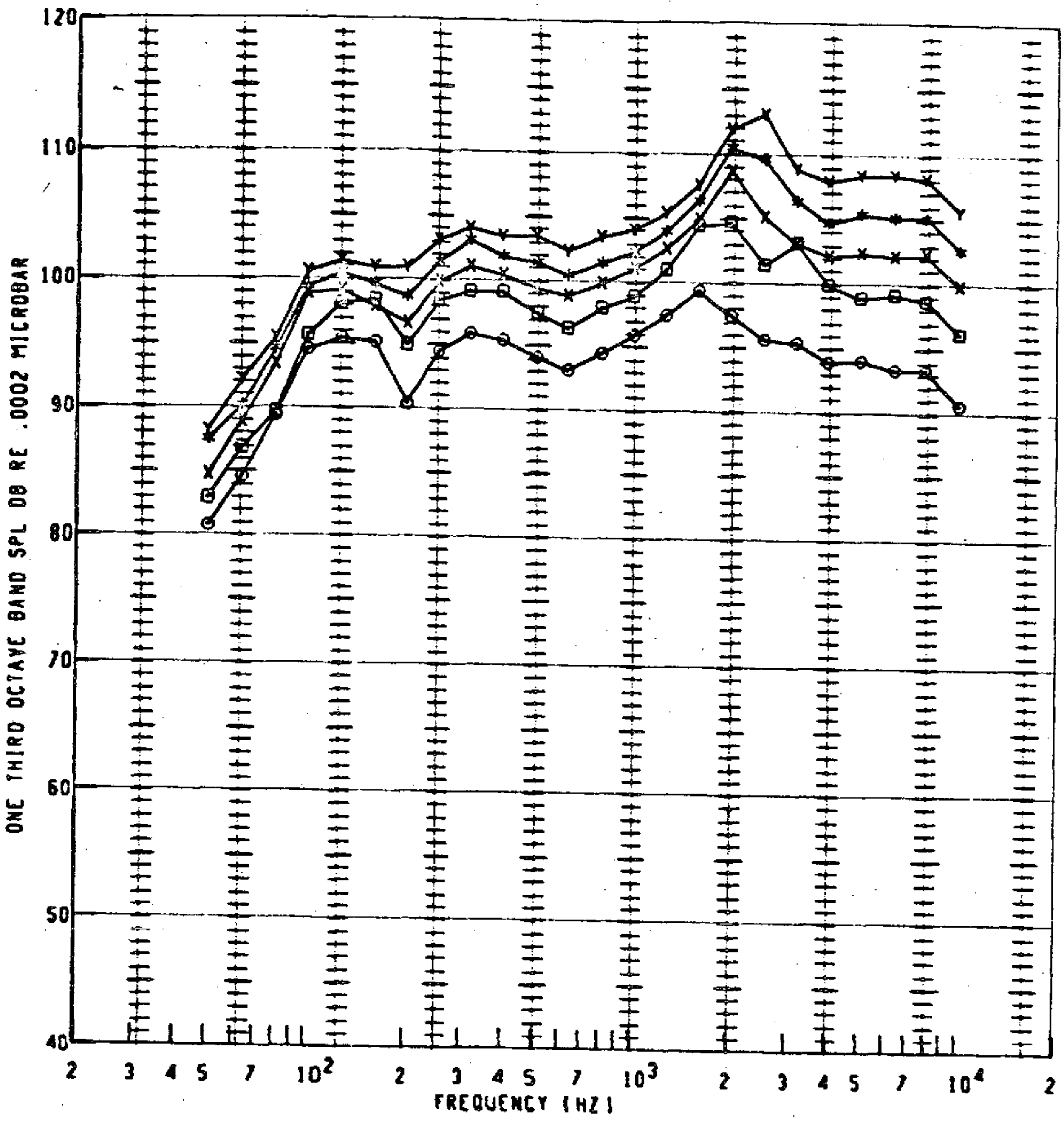
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	9	-0	1.300	120G	50FP	108.5	20	750 F
⊡	9	-0	1.400	120G	50FP	113.2	10	800 F
X	9	-0	1.500	120G	50FP	115.5	10	850 F
*	9	-0	1.600	120G	50FP	117.5	10	900 F
Y	9	-0	1.700	120G	50FP	119.7	0	950 F

FIGURE 84.—BUFFALO NOZZLE JET NOISE SUPPRESSION

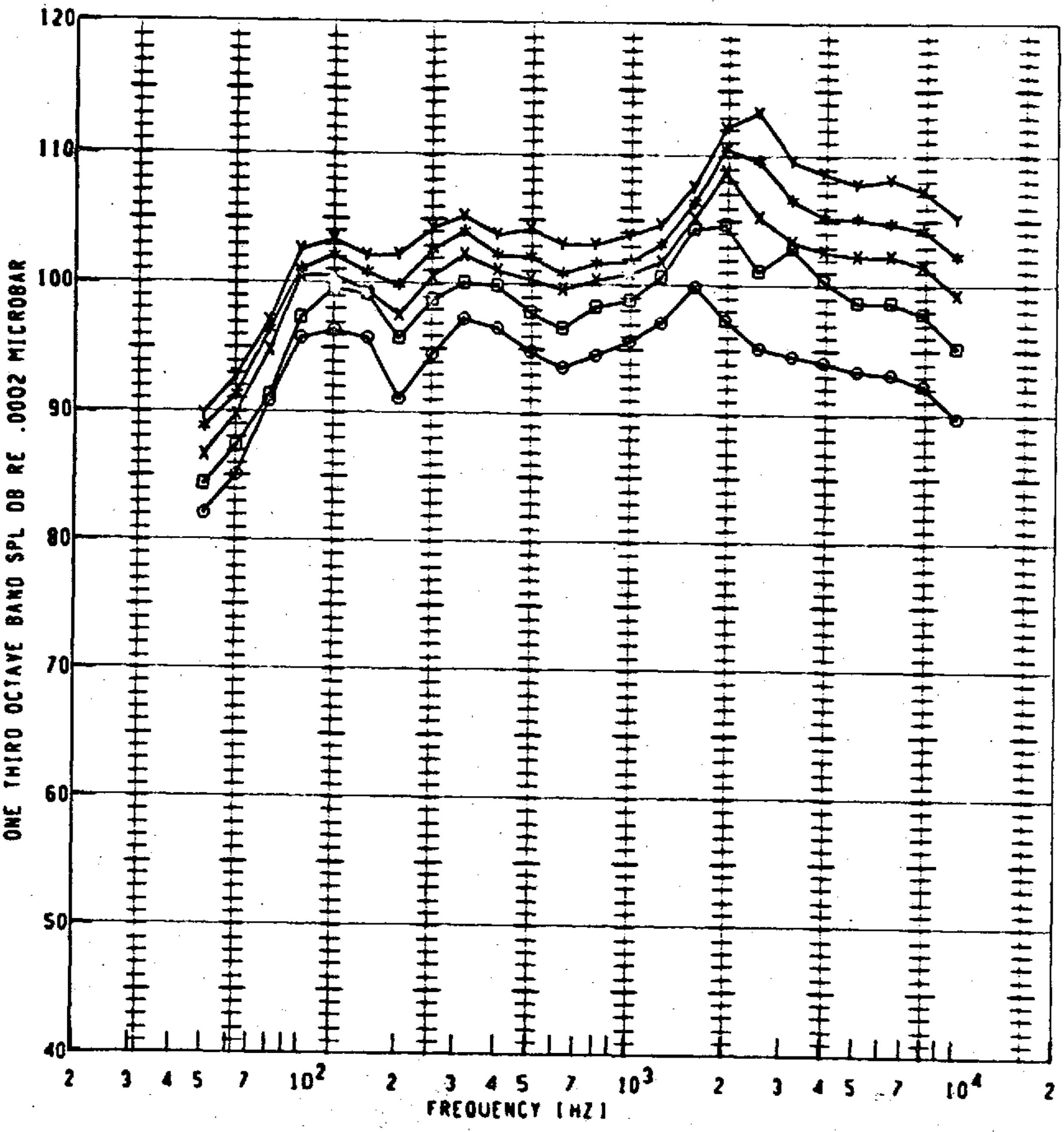
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	9	-0	1.300	125G	50FP	108.6	20	750 F
⊡	9	-0	1.400	125G	50FP	113.4	10	800 F
X	9	-0	1.500	125G	50FP	115.6	10	850 F
*	9	-0	1.600	125G	50FP	117.9	10	900 F
Y	9	-0	1.700	125G	50FP	120.6	0	950 F

FIGURE 85.—BUFFALO NOZZLE JET NOISE SUPPRESSION

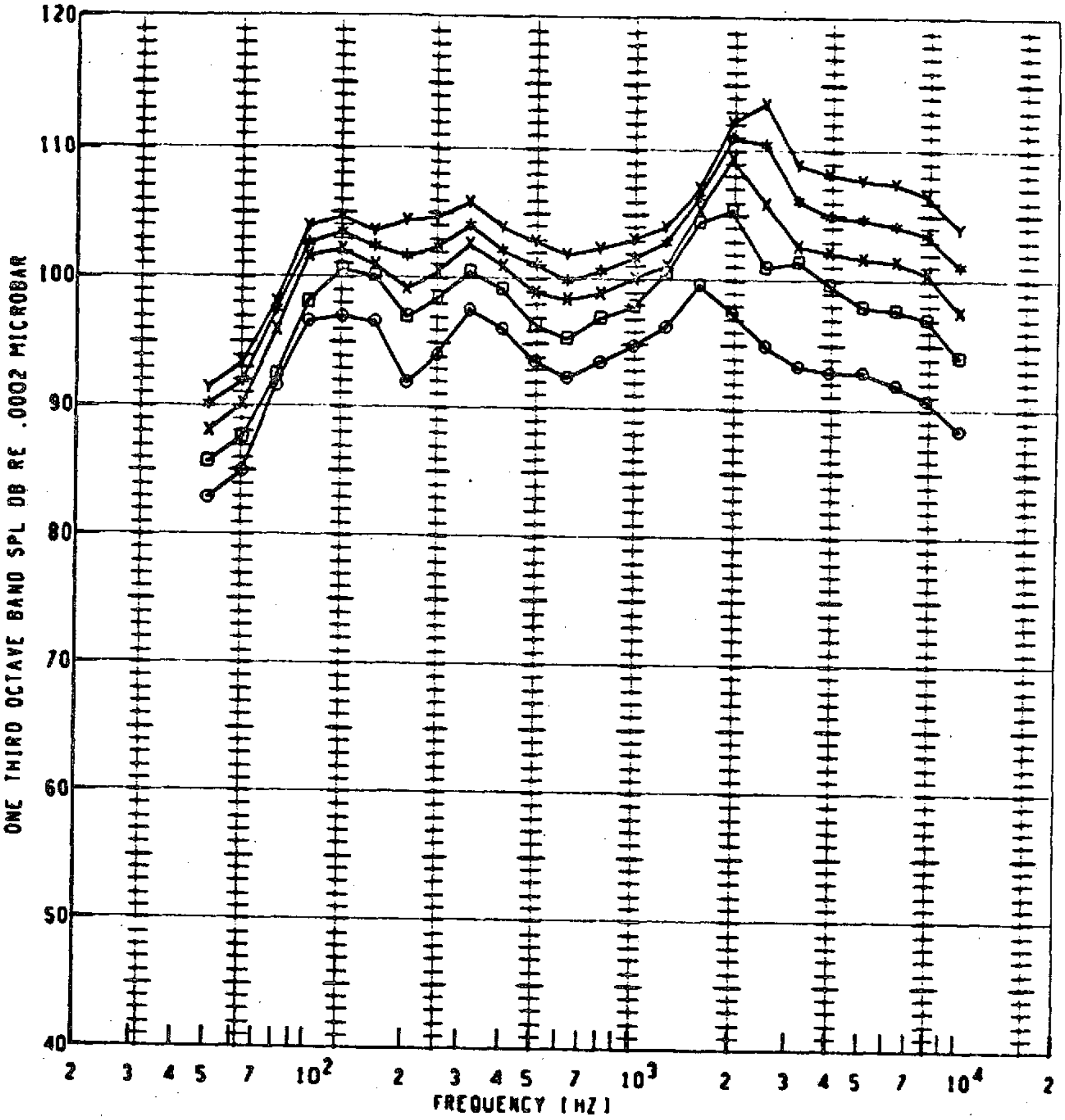
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	9	-0	1.300	130G	50FP	109.3	20	750 F
⊡	9	-0	1.400	130G	50FP	113.6	10	800 F
X	9	-0	1.500	130G	50FP	115.6	10	850 F
*	9	-0	1.600	130G	50FP	117.8	0	900 F
Y	9	-0	1.700	130G	50FP	120.8	0	950 F

FIGURE 86.—BUFFALO NOZZLE JET NOISE SUPPRESSION

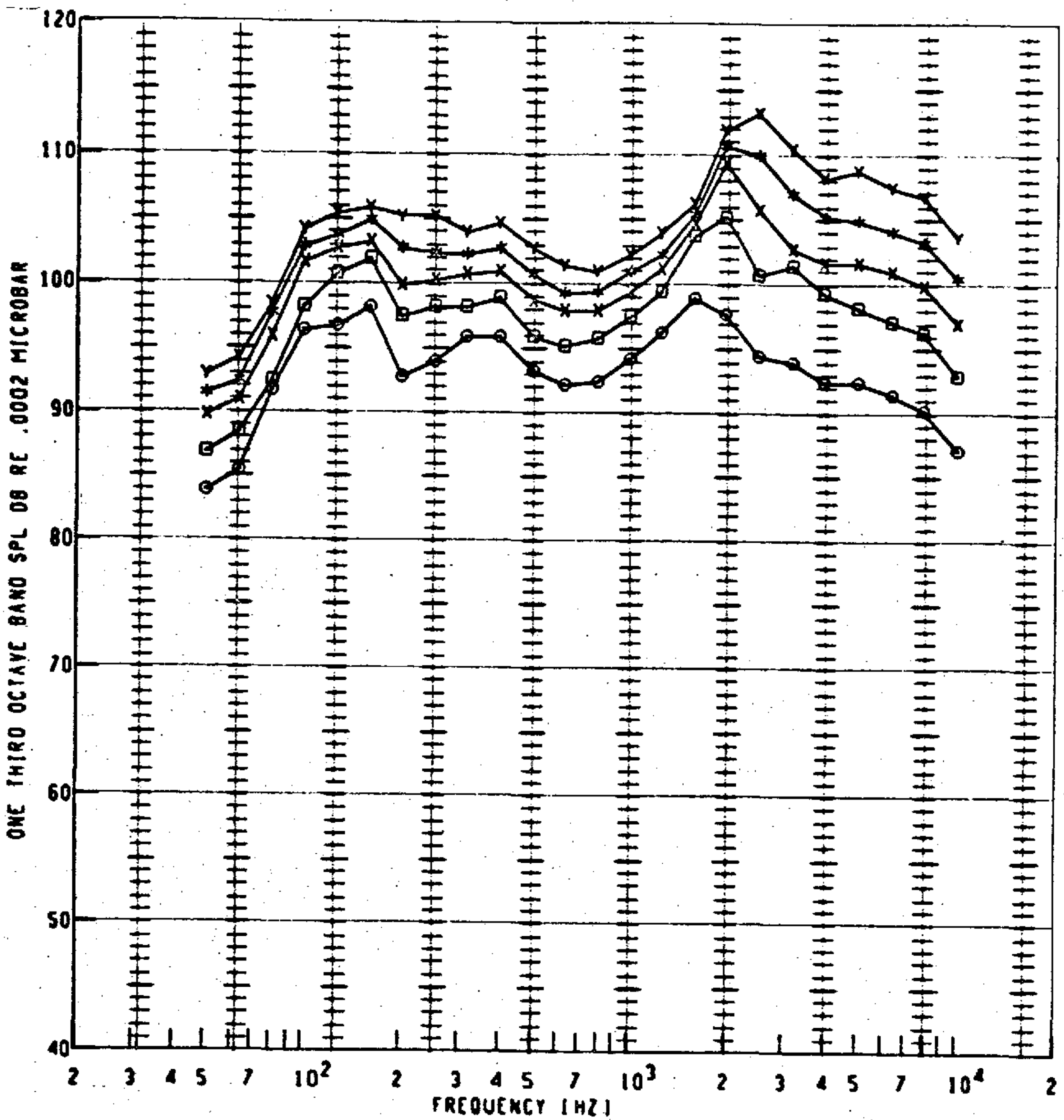
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	9	-0	1.300	135G	50FP	109.1	20	750 F
⊡	9	-0	1.400	135G	50FP	113.4	10	800 F
X	9	-0	1.500	135G	50FP	115.9	10	850 F
*	9	-0	1.600	135G	50FP	118.4	0	900 F
Y	9	-0	1.700	135G	50FP	120.6	0	950 F

FIGURE 87.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	9	-0	1.300	140G	50FP	108.7	20	750 F
⊡	9	-0	1.400	140G	50FP	113.2	10	800 F
X	9	-0	1.500	140G	50FP	115.9	10	850 F
*	9	-0	1.600	140G	50FP	118.4	0	900 F
Y	9	-0	1.700	140G	50FP	120.7	0	950 F

FIGURE 88.—BUFFALO NOZZLE JET NOISE SUPPRESSION

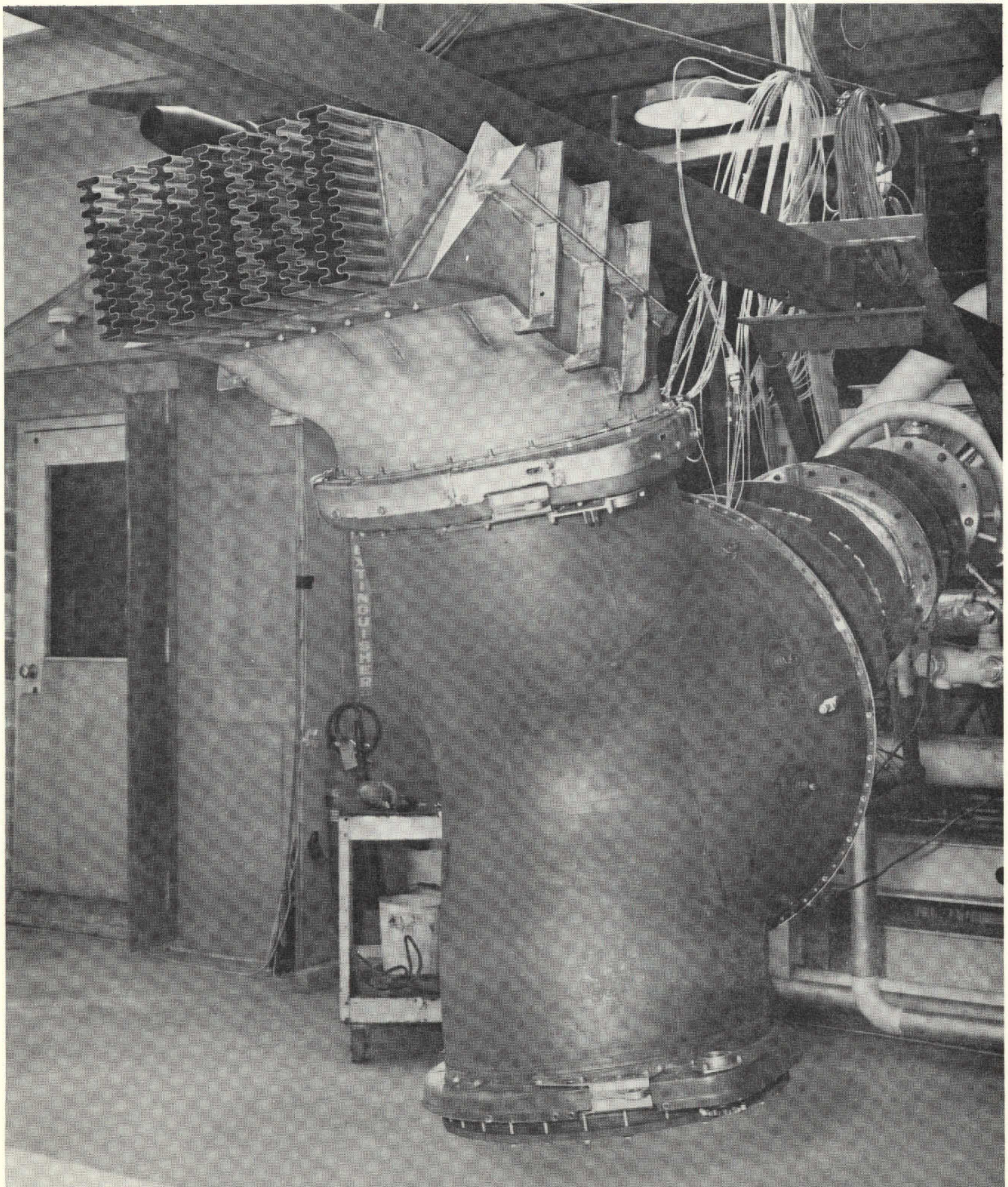


FIGURE 89.—BNS-3 LOBE NOZZLE WITH CORRUGATED CONVERGENT ENDS

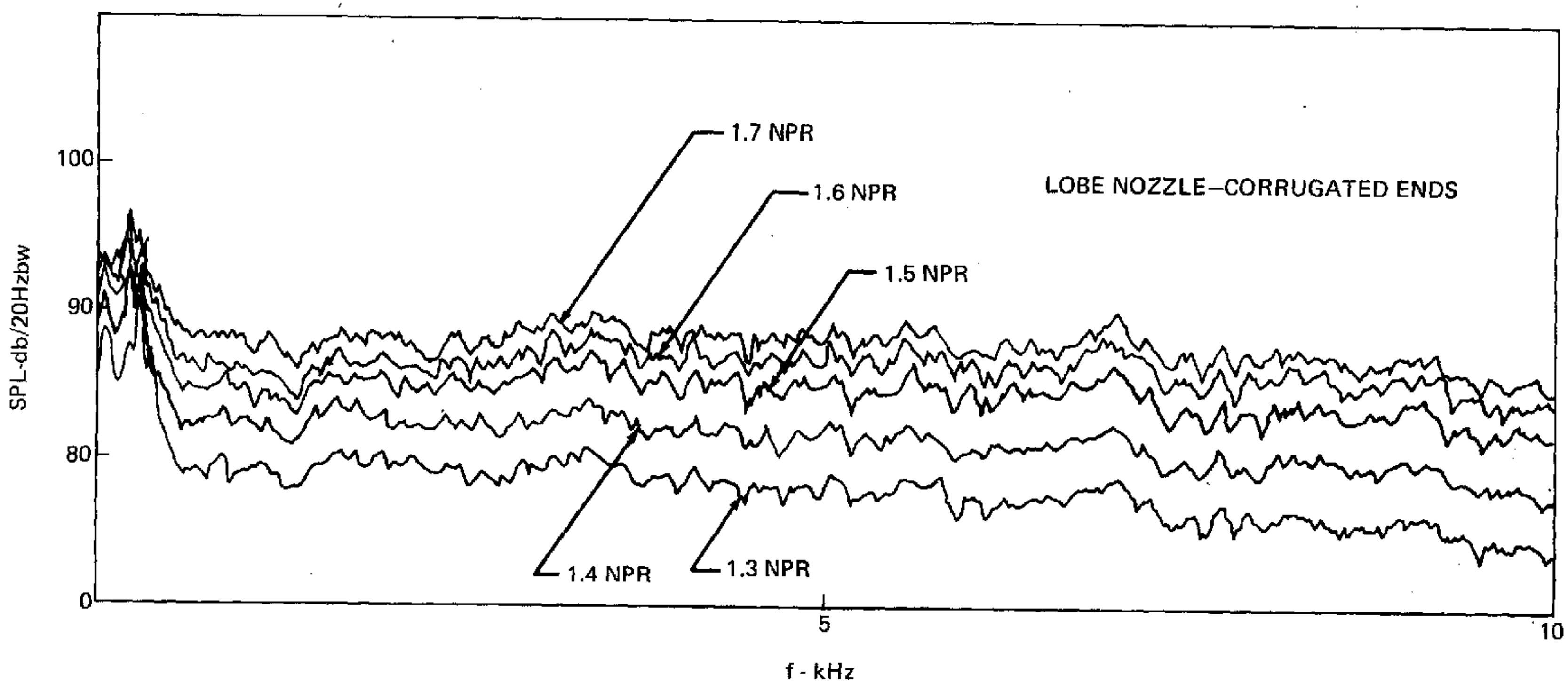
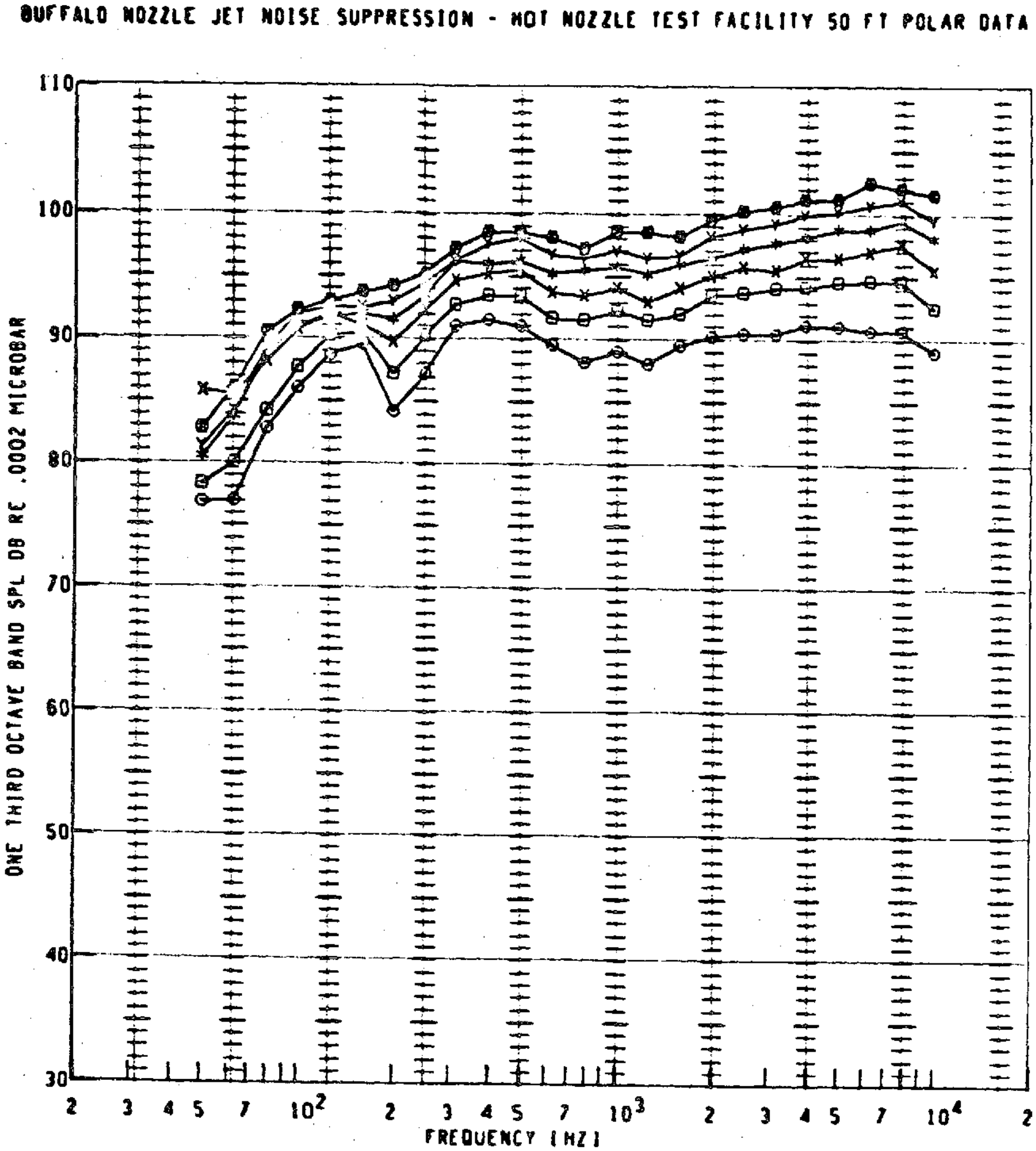
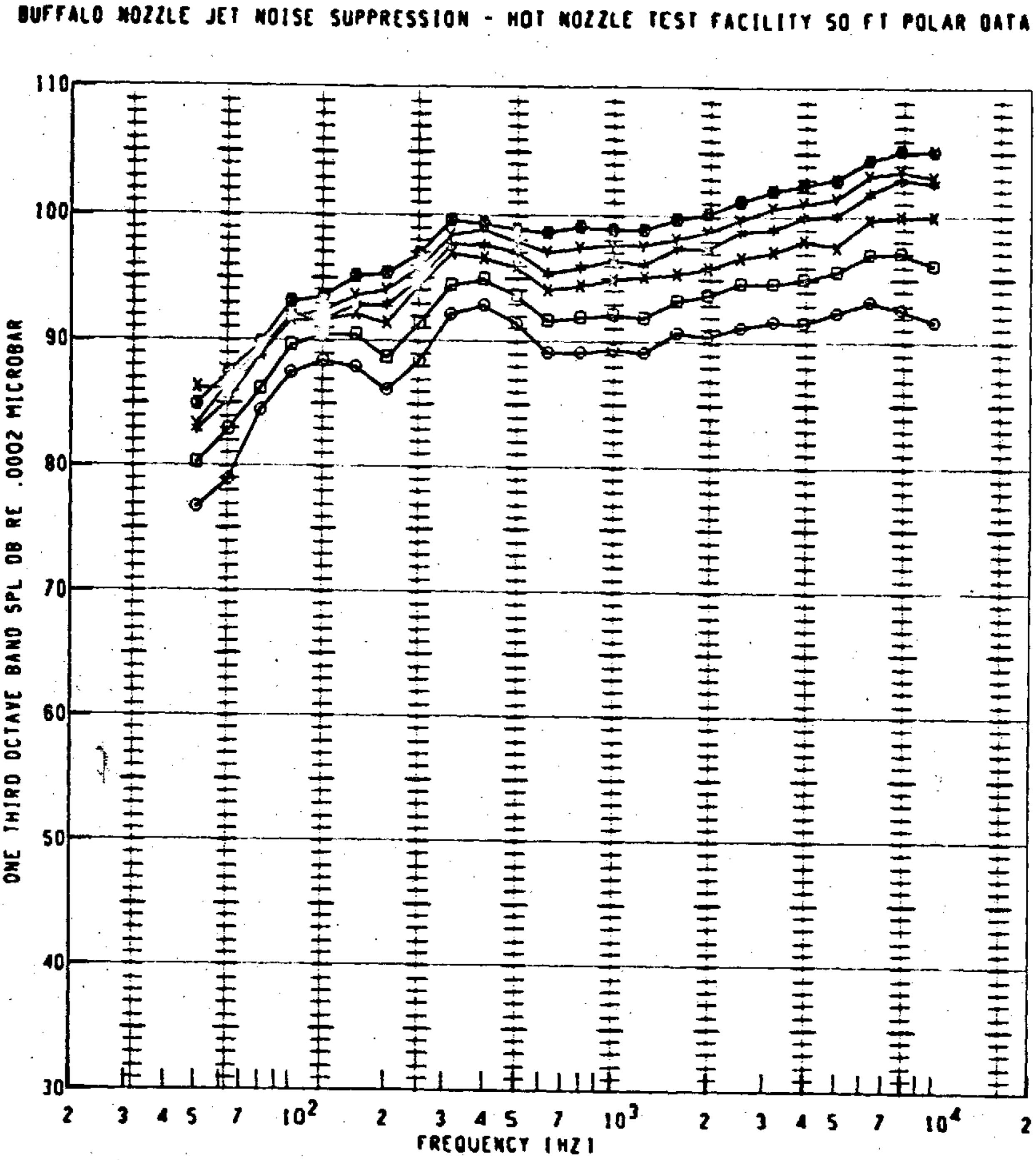


FIGURE 90.–NARROW-BAND ACOUSTICS OF RUN 12 AT 115° ANGLE



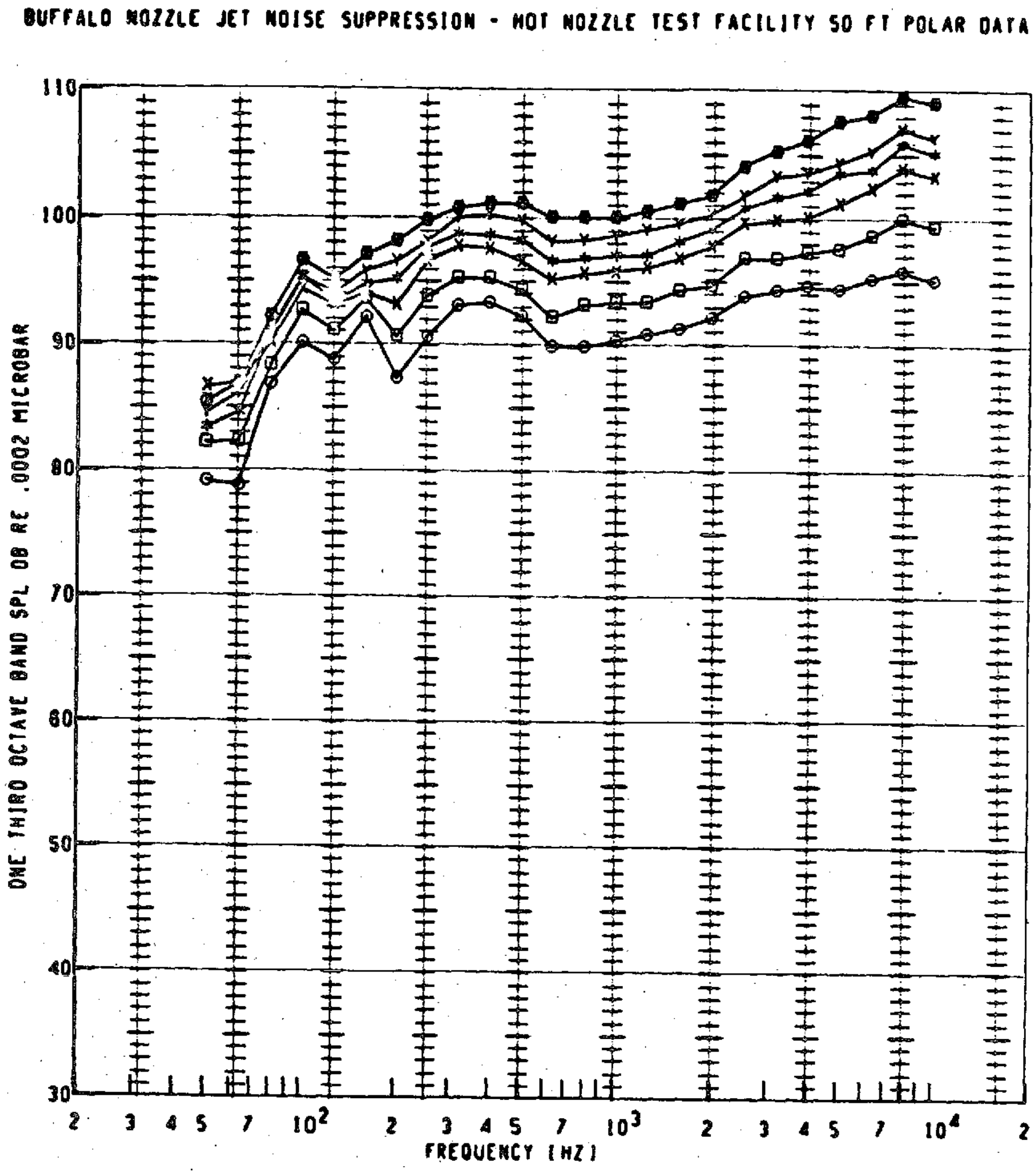
PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	12	-0	1.300	90G	50FP	103.2	20	750 F
⊡	12	-0	1.400	90G	50FP	106.0	10	800 F
X	12	-0	1.500	90G	50FP	108.2	10	850 F
*	12	-0	1.600	90G	50FP	109.7	10	900 F
Y	12	-0	1.700	90G	50FP	111.2	10	950 F
●	12	-0	1.800	90G	50FP	112.7	10	950 F

FIGURE 91.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	12	-0	1.300	100G	50FP	104.6	20	750 F
⊡	12	-0	1.400	100G	50FP	108.1	10	800 F
X	12	-0	1.500	100G	50FP	111.1	10	850 F
*	12	-0	1.600	100G	50FP	112.6	10	900 F
Y	12	-0	1.700	100G	50FP	114.1	10	950 F
●	12	-0	1.800	100G	50FP	115.1	0	950 F

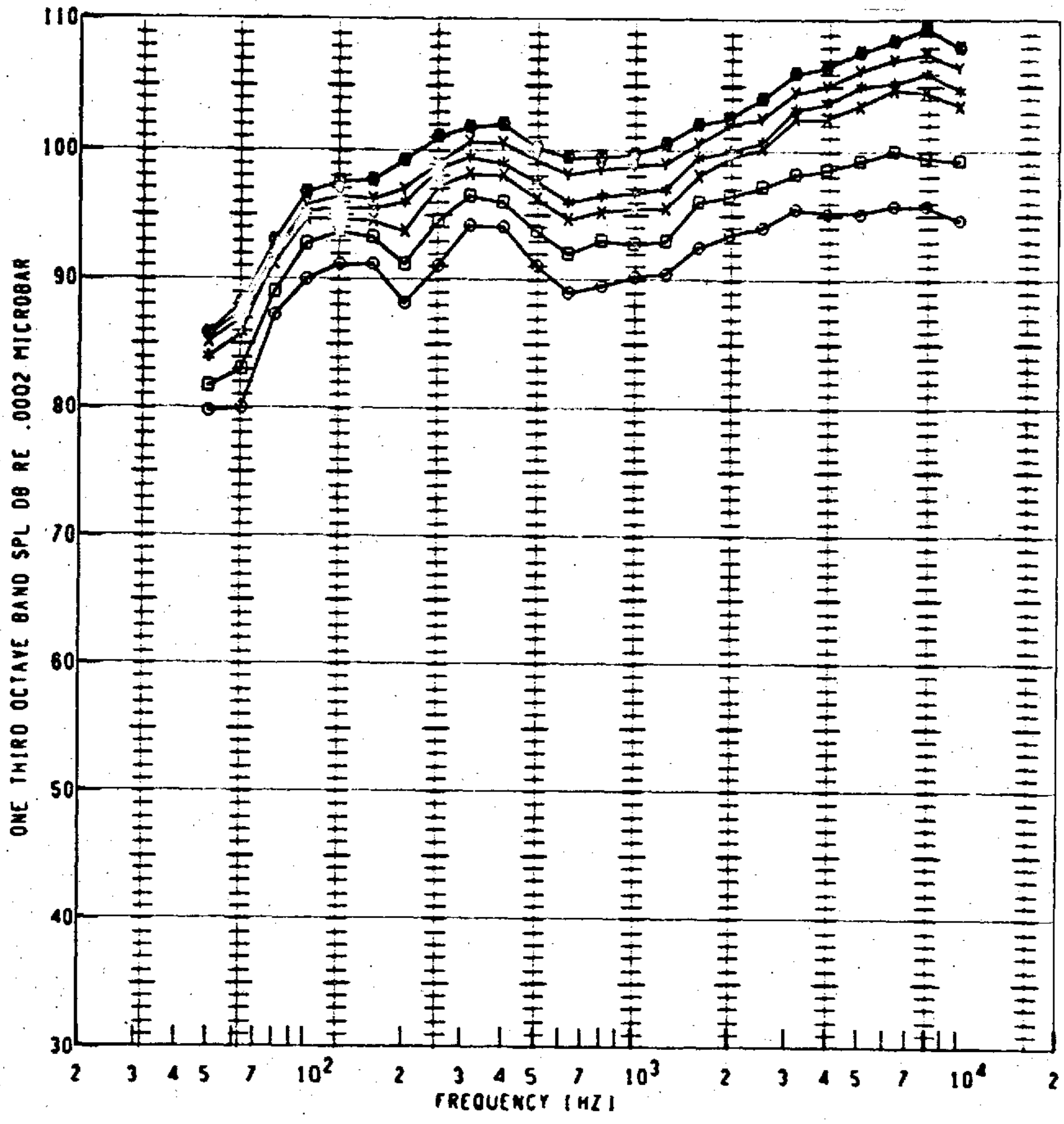
FIGURE 92.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	12	-0	1.300	110G	50FP	106.6	20	750 F
⊡	12	-0	1.400	110G	50FP	110.1	10	800 F
X	12	-0	1.500	110G	50FP	113.1	10	850 F
*	12	-0	1.600	110G	50FP	114.8	10	900 F
Y	12	-0	1.700	110G	50FP	115.8	0	950 F
●	12	-0	1.800	110G	50FP	118.1	0	950 F

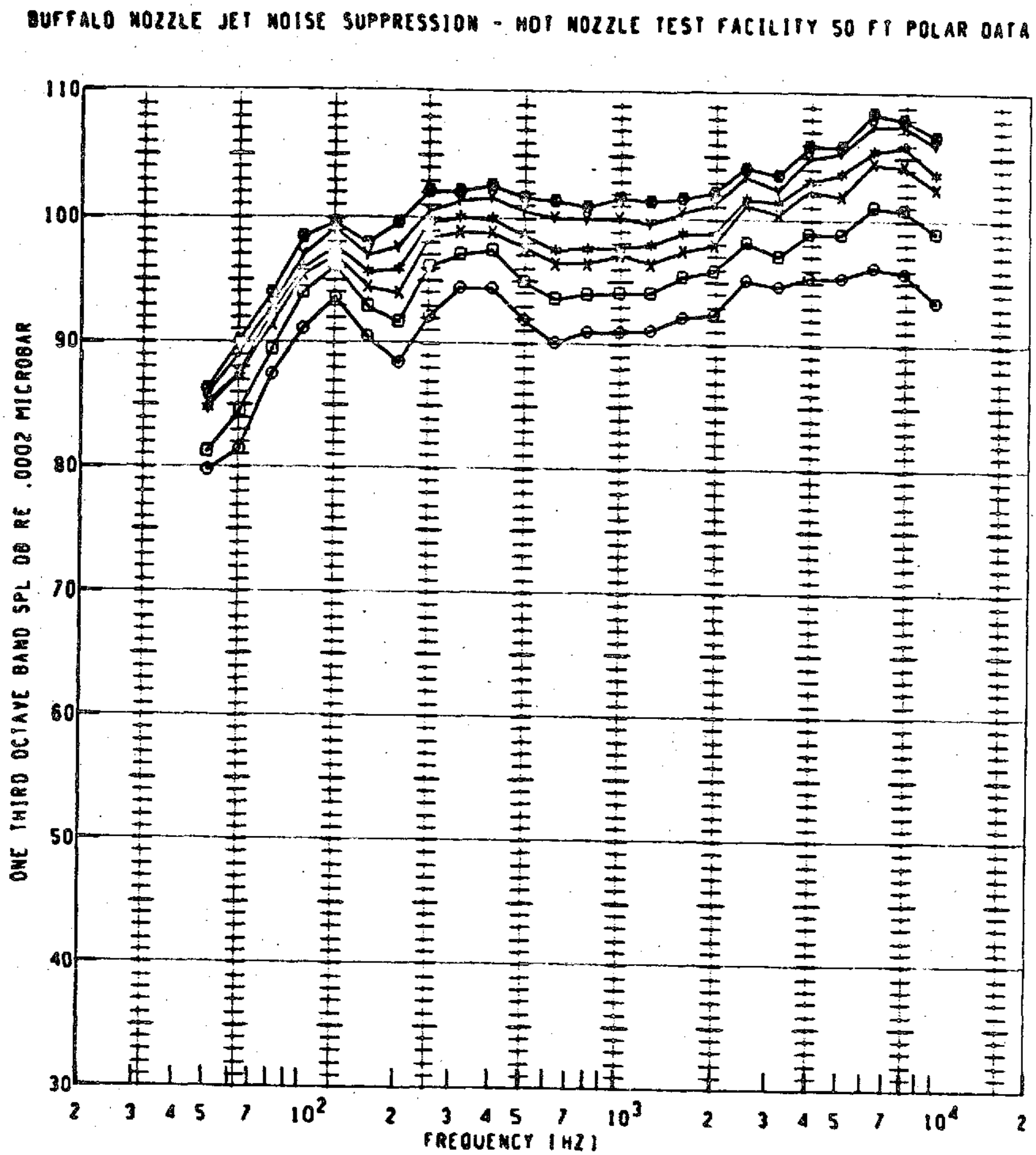
FIGURE 93.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	12	-0	1.300	115G	50FP	106.5	20	750 F
⊡	12	-0	1.400	115G	50FP	110.0	10	800 F
X	12	-0	1.500	115G	50FP	113.5	10	850 F
*	12	-0	1.600	115G	50FP	114.7	10	900 F
Y	12	-0	1.700	115G	50FP	116.2	0	950 F
●	12	-0	1.800	115G	50FP	117.7	0	950 F

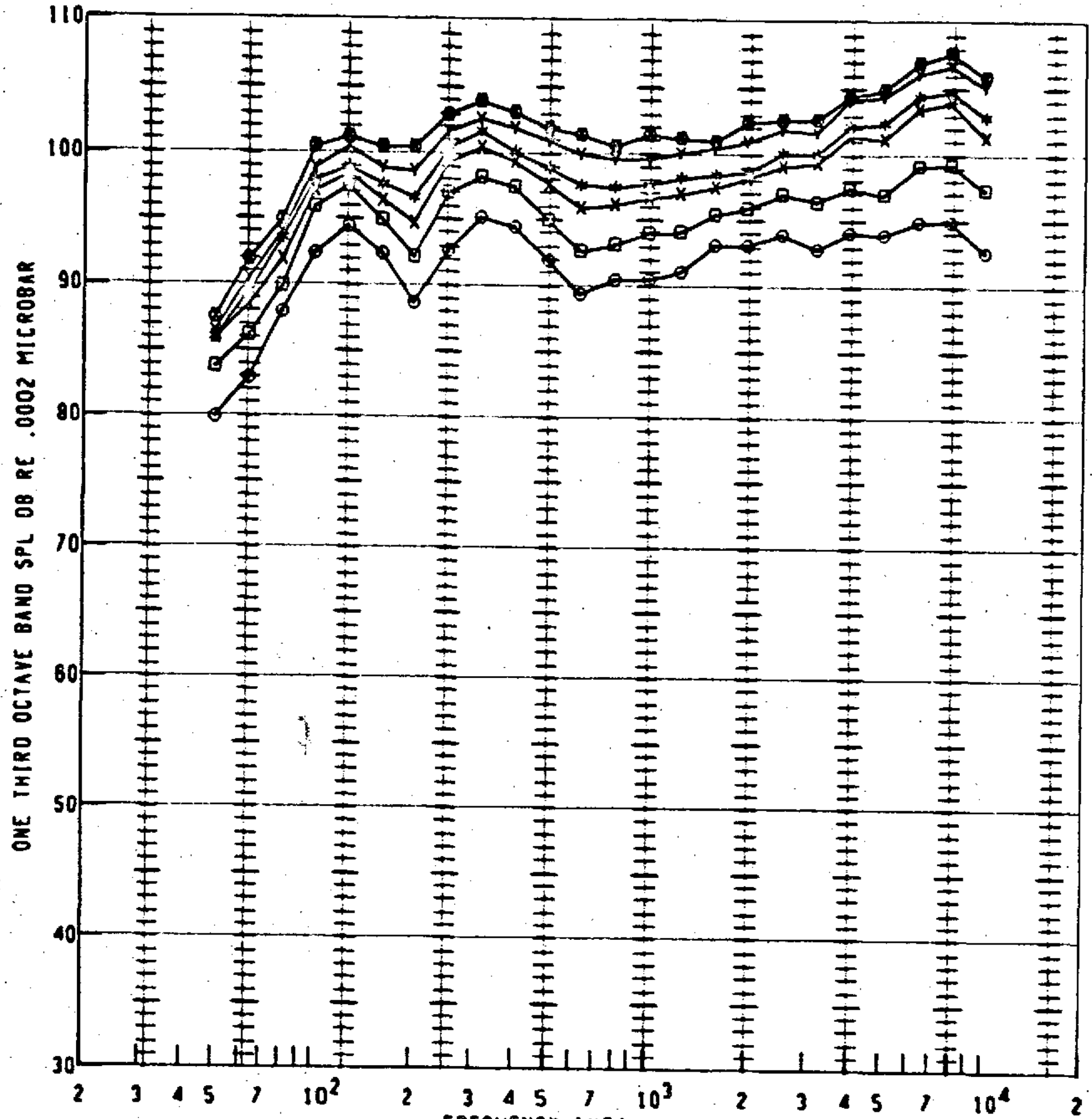
FIGURE 94.—BUFFALO NOZZLE JET NOISE SUPPRESSION



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	12	-0	1.300	120G	50FP	107.4	20	750 F
⊡	12	-0	1.400	120G	50FP	111.1	10	800 F
X	12	-0	1.500	120G	50FP	113.6	10	850 F
*	12	-0	1.600	120G	50FP	114.6	10	900 F
Y	12	-0	1.700	120G	50FP	116.9	0	950 F
●	12	-0	1.800	120G	50FP	117.1	0	950 F

FIGURE 95.—BUFFALO NOZZLE JET NOISE SUPPRESSION

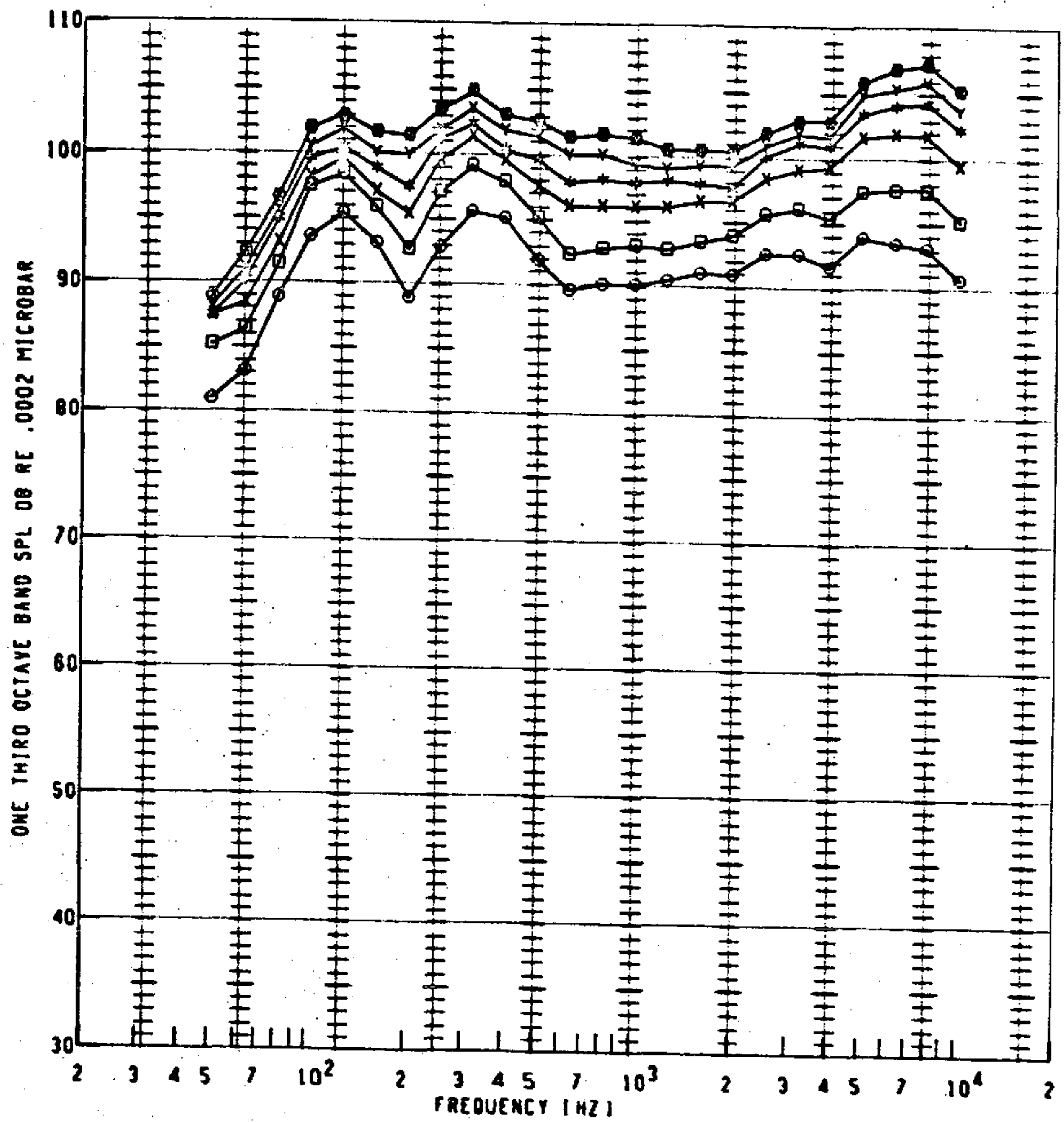
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	12	-0	1.300	125G	50FP	106.9	20	750 F
⊡	12	-0	1.400	125G	50FP	109.9	10	800 F
X	12	-0	1.500	125G	50FP	113.1	10	850 F
*	12	-0	1.600	125G	50FP	113.6	10	900 F
Y	12	-0	1.700	125G	50FP	116.4	0	950 F
⊕	12	-0	1.800	125G	50FP	116.9	0	950 F

FIGURE 96.—BUFFALO NOZZLE JET NOISE SUPPRESSION

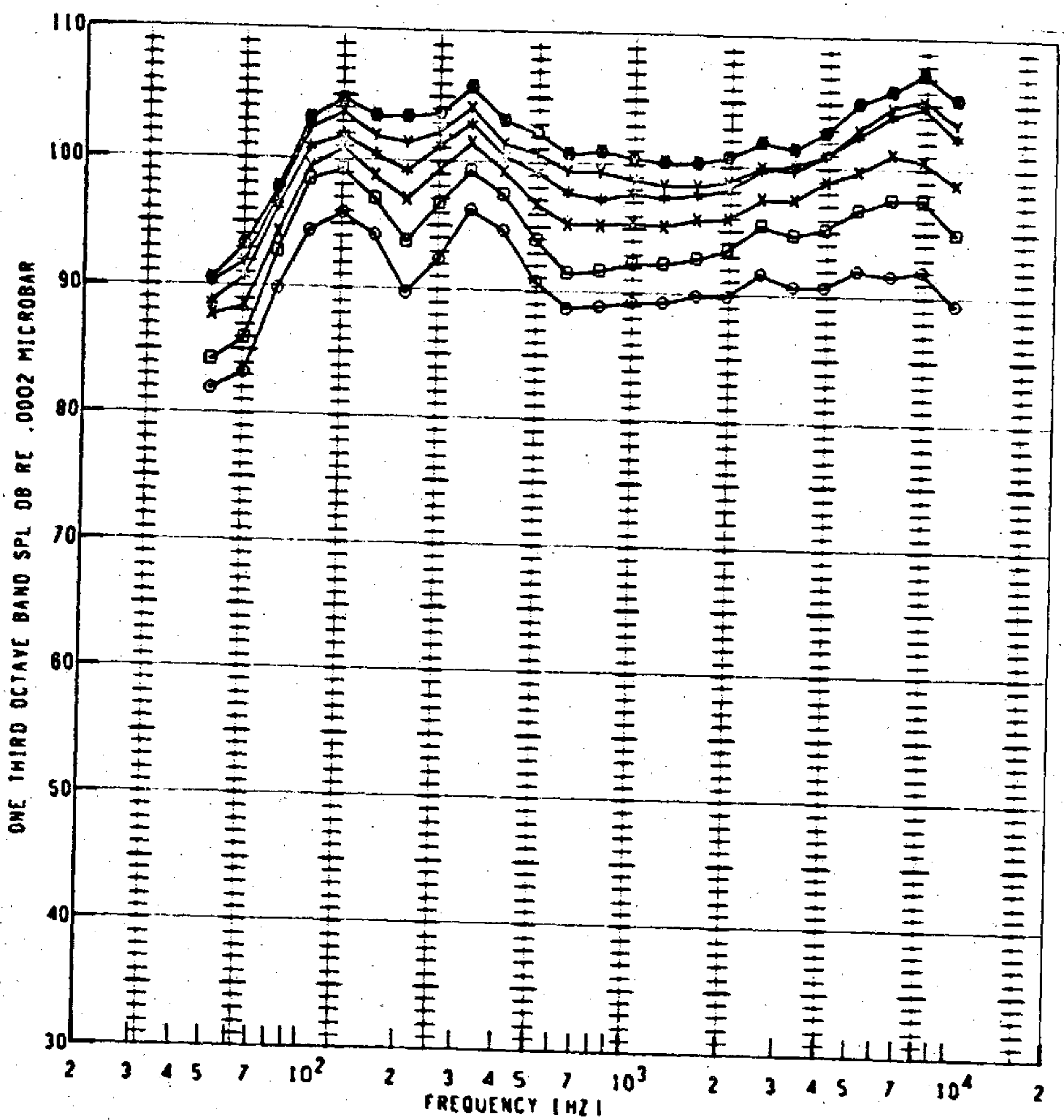
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	12	-0	1.300	130G	50FP	106.1	20	750 F
⊡	12	-0	1.400	130G	50FP	109.9	10	800 F
X	12	-0	1.500	130G	50FP	112.1	10	850 F
*	12	-0	1.600	130G	50FP	113.9	10	900 F
Y	12	-0	1.700	130G	50FP	115.9	0	950 F
●	12	-0	1.800	130G	50FP	117.4	0	950 F

FIGURE 97.—BUFFALO NOZZLE JET NOISE SUPPRESSION

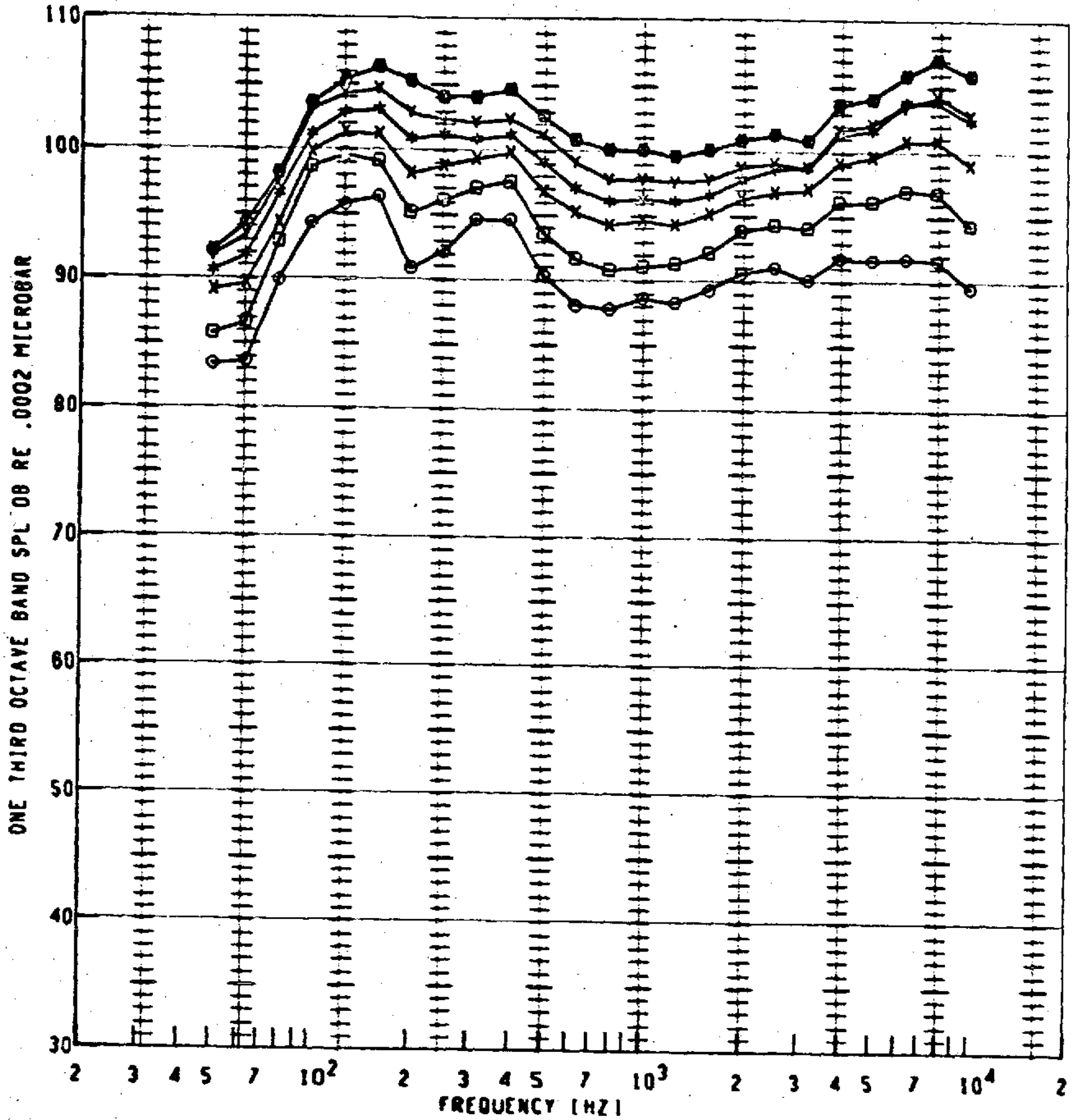
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	12	-0	1.300	135G	50FP	105.7	20	750 F
⊡	12	-0	1.400	135G	50FP	109.7	10	800 F
X	12	-0	1.500	135G	50FP	111.9	10	850 F
*	12	-0	1.600	135G	50FP	114.4	10	900 F
Y	12	-0	1.700	135G	50FP	115.7	0	950 F
●	12	-0	1.800	135G	50FP	117.4	0	950 F

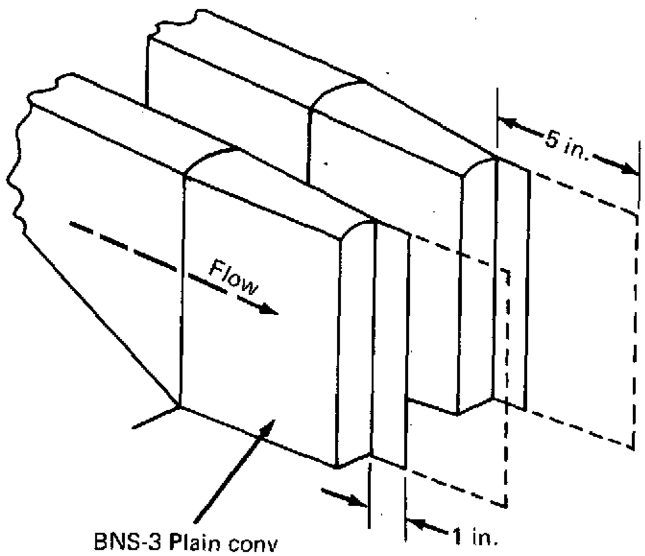
FIGURE 98.—BUFFALO NOZZLE JET NOISE SUPPRESSION

BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	12	-0	1.300	140G	50FP	105.6	20	750 F
⊡	12	-0	1.400	140G	50FP	109.6	10	800 F
X	12	-0	1.500	140G	50FP	112.1	10	850 F
*	12	-0	1.600	140G	50FP	114.6	10	900 F
Y	12	-0	1.700	140G	50FP	116.1	0	950 F
●	12	-0	1.800	140G	50FP	117.6	0	950 F

FIGURE 99.—BUFFALO NOZZLE JET NOISE SUPPRESSION



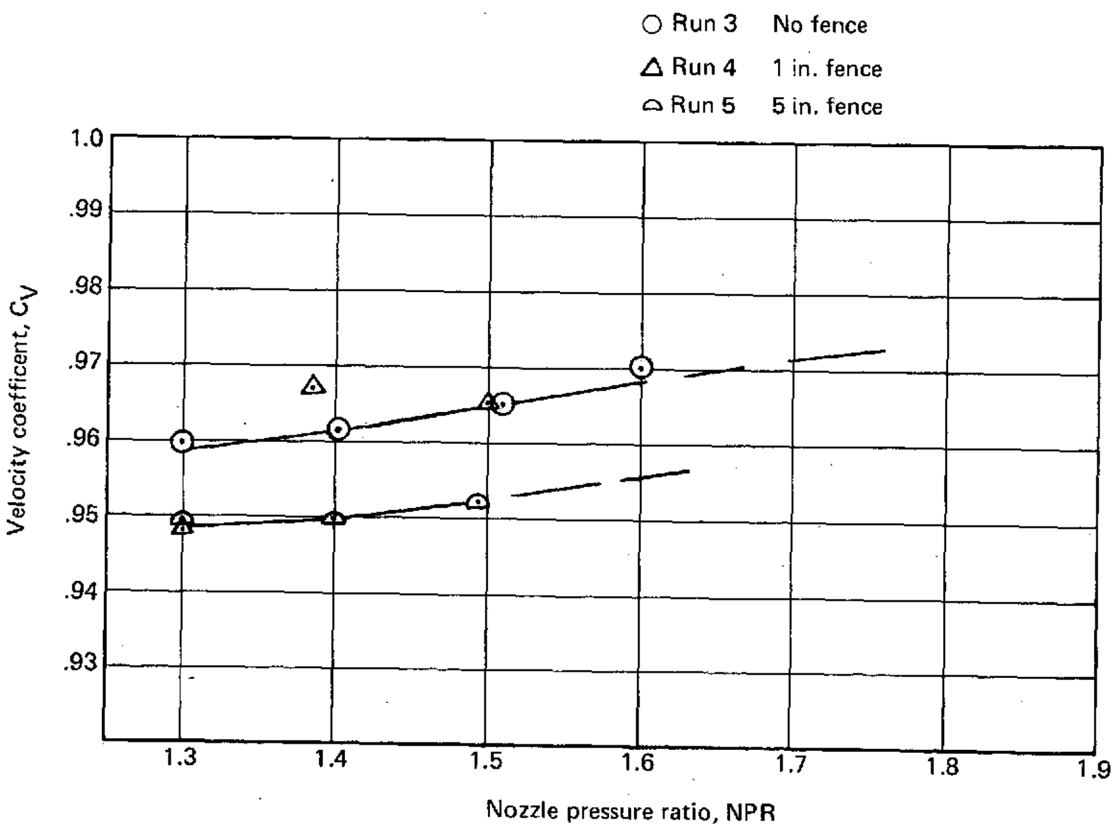


FIGURE 100.—PERFORMANCE EFFECTS OF FENCES ATTACHED TO LOBE WALLS

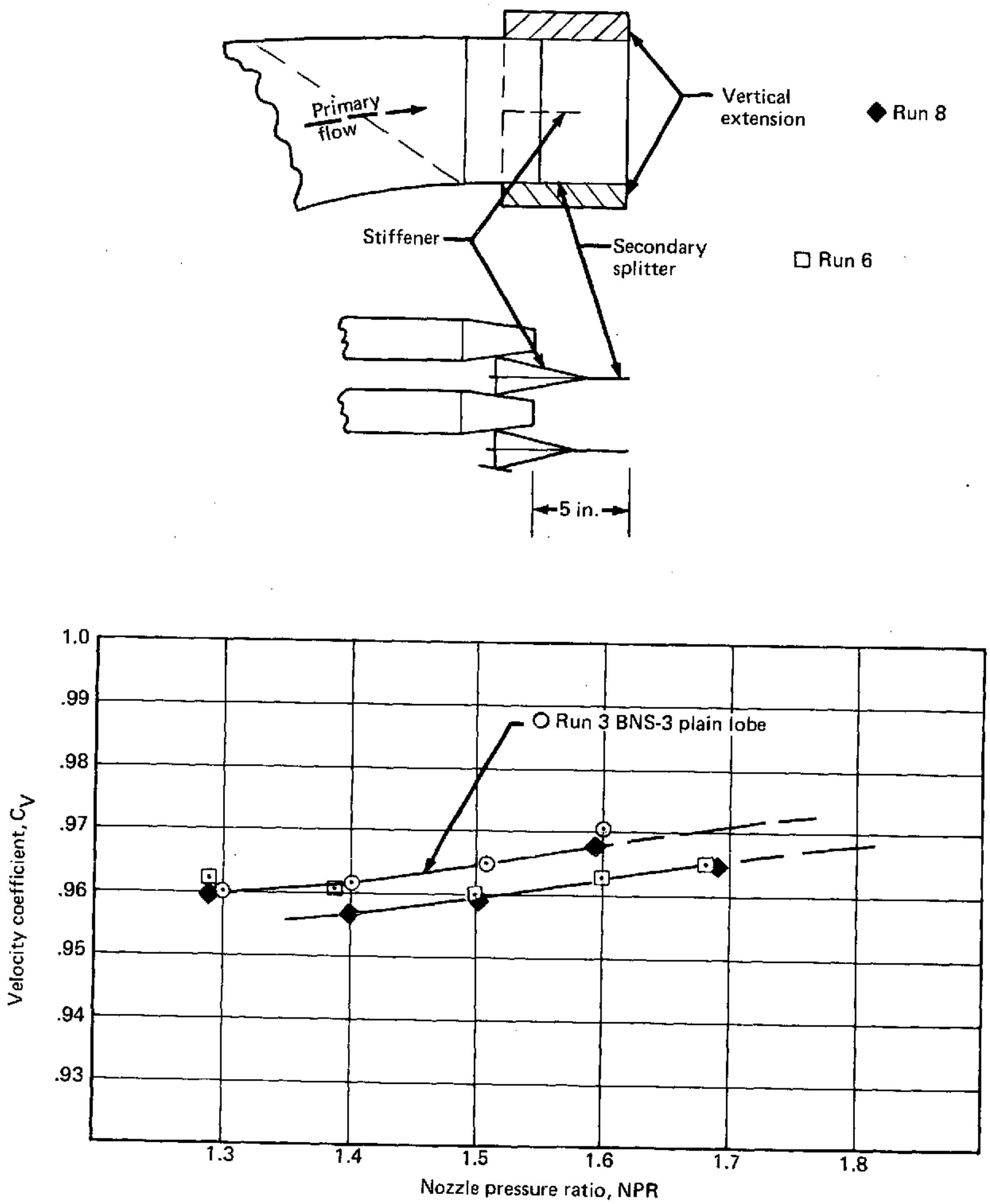


FIGURE 101.—PERFORMANCE EFFECTS OF SECONDARY SPLITTER FENCE

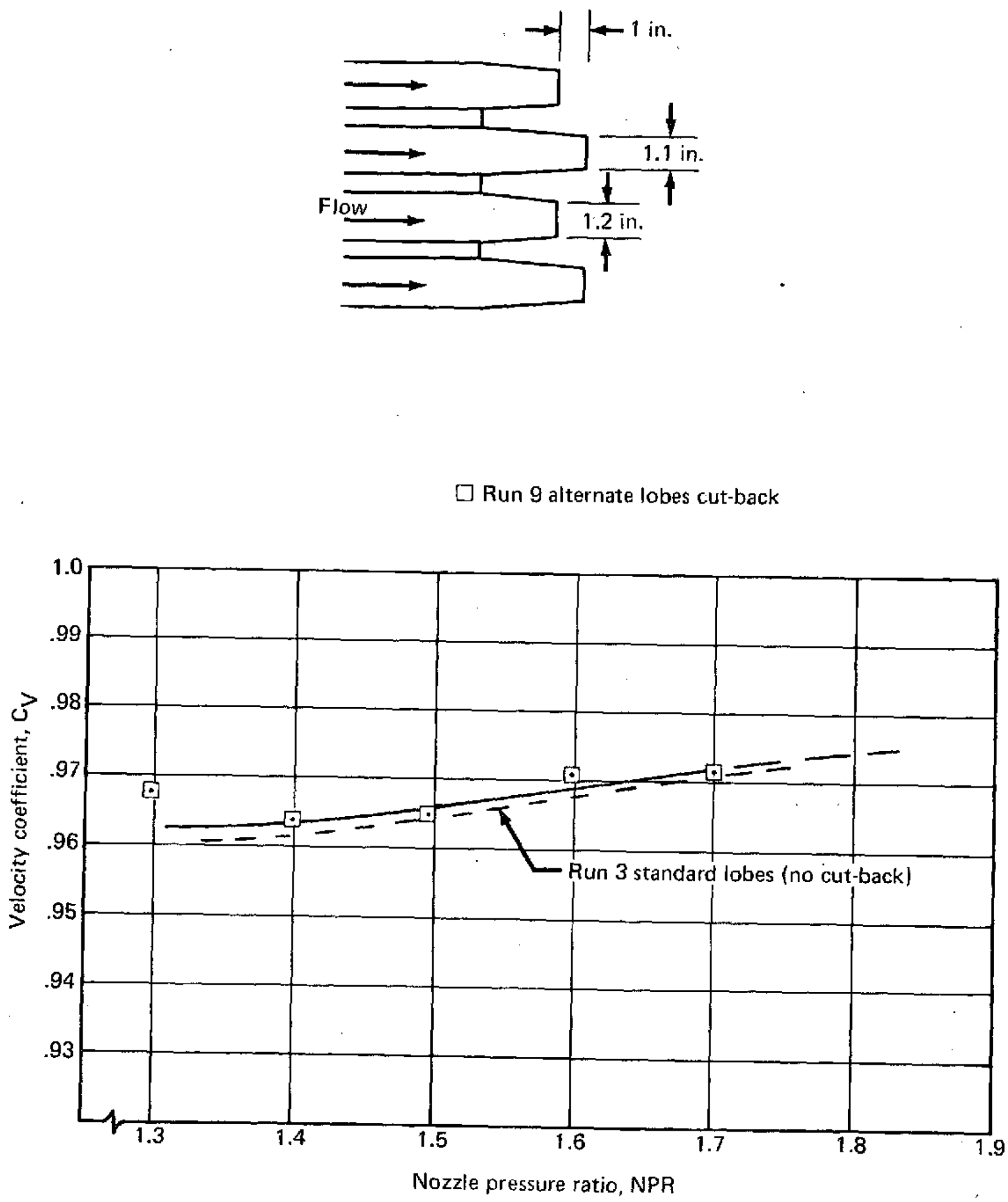
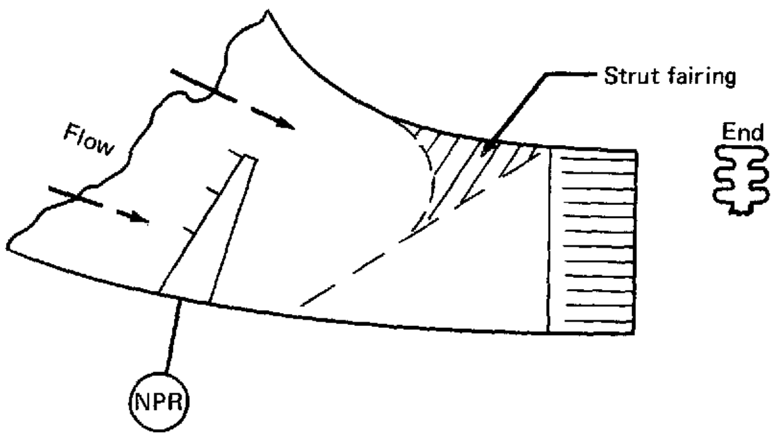


FIGURE 102.—PERFORMANCE EFFECT OF CUTTING BACK ALTERNATE LOBES



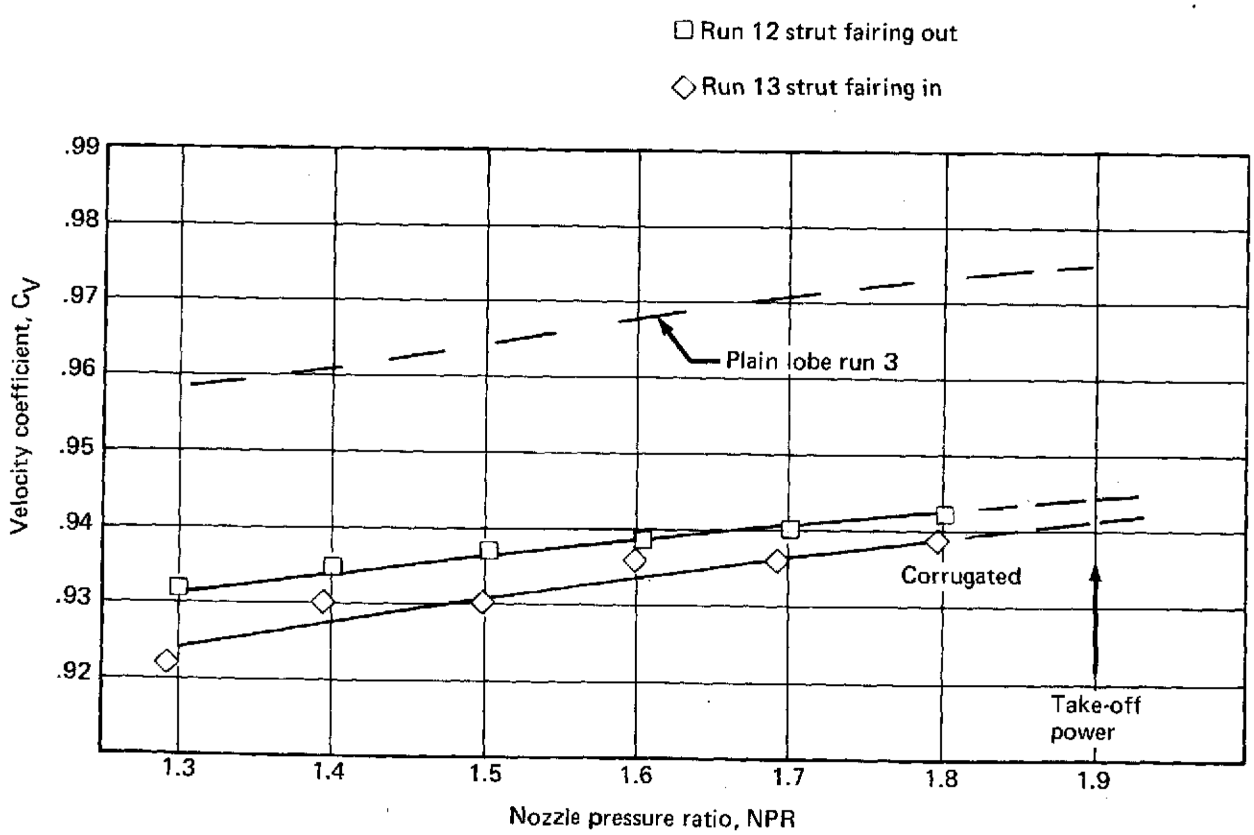


FIGURE 103.–PERFORMANCE COMPARISON OF PLAIN AND CORRUGATED NOZZLES

APPENDIX A

ORIGINAL TEST PLAN

BUFFALO SUPPRESSOR NOZZLE ACOUSTIC AND PERFORMANCE TEST – FLIGHT DESIGN CONFIGURATION

Acoustic tests conducted at Boeing on one of the lobe-type jet suppressor nozzles (BNS-1), designed for the Buffalo augmentor wing aircraft, demonstrated that a strong tone (2 kHz) generated by the nozzle can be eliminated and excellent flyover noise suppression is available due to directivity effects as described in reference 2. This basic jet suppressor design, with further improvements, can be considered as an effective jet noise suppressor for the Buffalo aircraft. Additional suppression is believed available with minimum thrust penalties by use of convergent corrugated nozzle ends. Structural and manufacturing requirements resulted in internal strut design changes and an increase in the lobe ramp angle.

The objectives of the test described herein are to measure the acoustic and thrust performance characteristics of convergent and corrugated nozzle designs and simulate the lobe ramp angle and internal struts that are required for the flight design.

TEST PLAN

The advanced lobe suppressor design (designed BNS-3) configuration will be created by installing the new lobe ends on the existing BNS-1 nozzle base and transition. (See fig. A-1). After the plain wall convergent nozzles are tested, the nozzle ends will be removed and replaced with the corrugated nozzle ends. As in the tone source test (ref. 2), the Boeing hot nozzle test facility will be used to measure the noise and thrust performance. (See fig. A-2).

The microphone layout and the acoustic test window are also shown on figure A-2. The test nozzle velocity and discharge coefficients will be computed as defined in reference 2.

For the following test configurations, record acoustic and performance data at each test condition. Acoustic recordings of 20 sec at each NPR are required. Acoustic analysis will be of one-third octave bands centered from 50 Hz through 10 kHz. A one-third octave on-line plot will be tied into the 115° microphone for quick look comparisons. Adequate stabilization time will be allowed prior to recording data to ensure high quality measurements.

TEST CONFIGURATIONS

Configuration	Nozzle end	Nozzle rotation	Internal strut fairing	NPR and temperature
BNS-1 a	Plain	0° b	n.a.	1.3 – 750°F. 1.4 – 800°F. 1.5 – 850°F. 1.6 – 900°F. 1.7 – 950°F.
BNS-3	Plain convergent	"	Off	
BNS-3	Plain convergent	"	On	
BNS-3	Corrugated convergent	"	On	
BNS-3	Corrugated convergent	"	Off	
BNS-3	(Fences instl .c)	"		

a Reference

b Sideline orientation

c Contingency test—if any tones are produced by the BNS-3 configurations, tests will be conducted to determine the minimum size of secondary fence required to eliminate the tone.

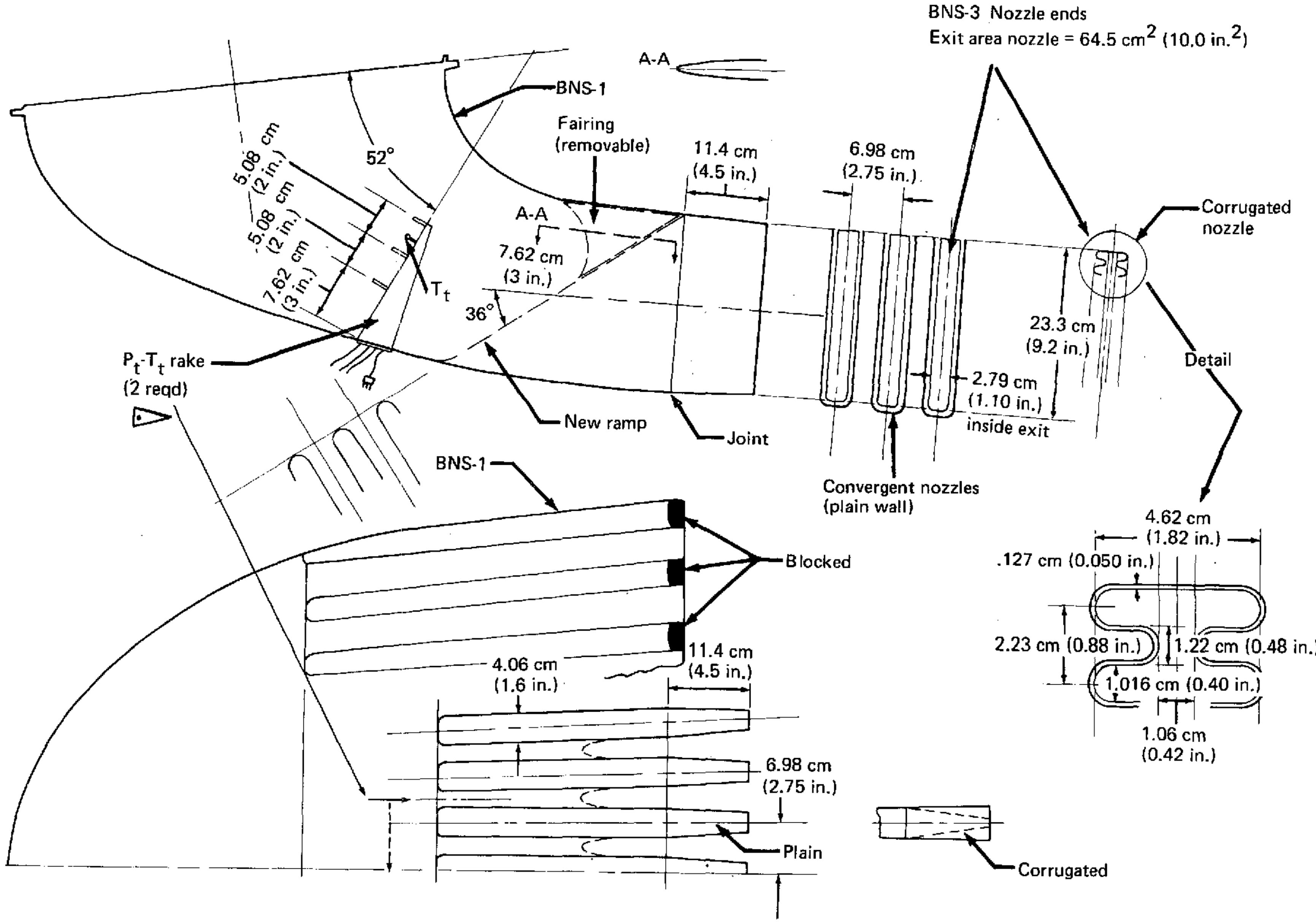


FIGURE A-1.—TEST HARDWARE DEFINITION BUFFALO NOISE—2ND ADD-ON

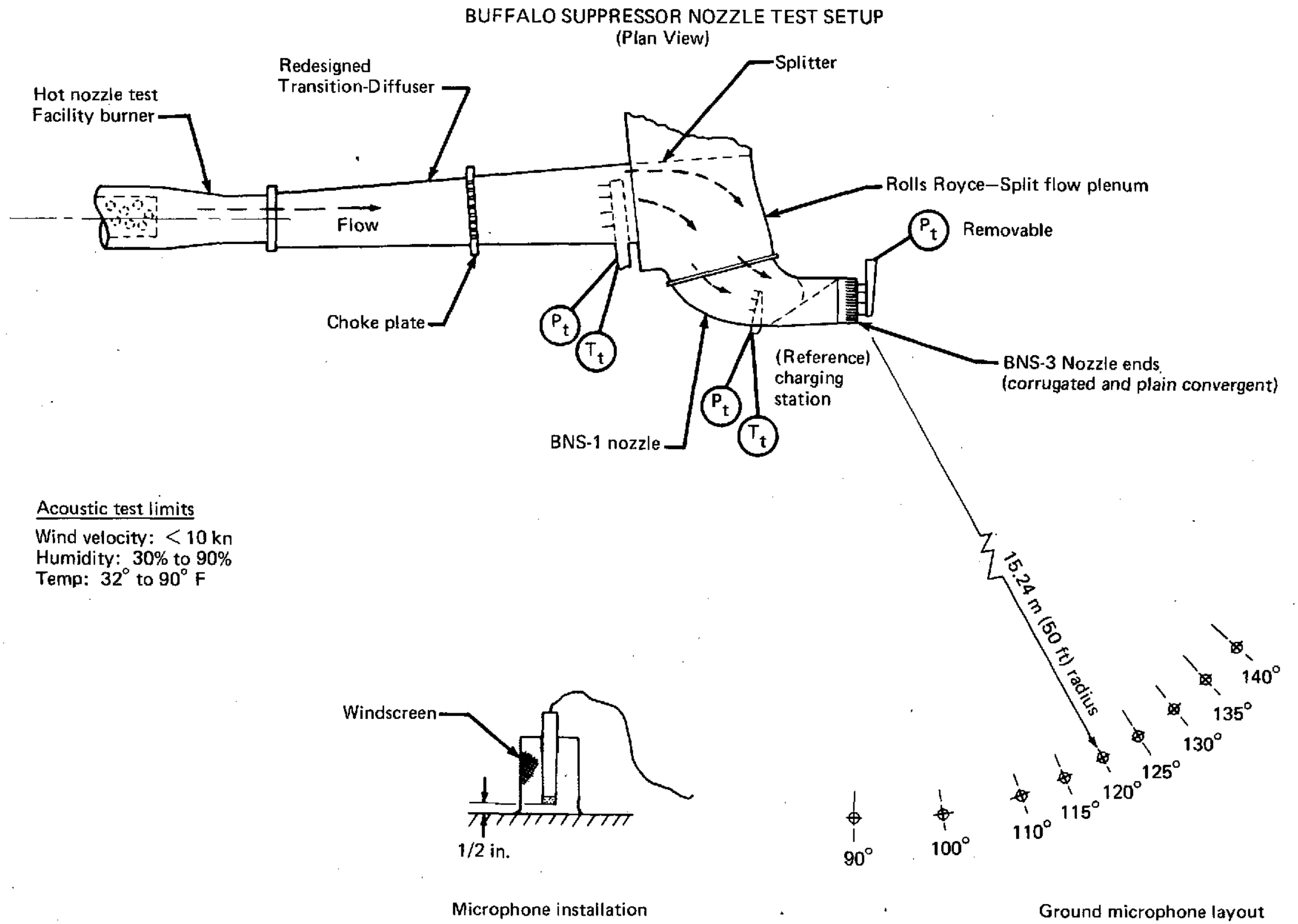


FIGURE A-2.—TEST SET-UP (PLAN VIEW) AND MICROPHONE LAYOUT

APPENDIX B

TEST LOG

Table B-1. Test Log

Run number	Config number	Condition number	Outside air temp °C/(°F)	Relative humidity (%)	Nozzle pressure ratio NPR	Exhaust gas temp °C/(°F)	Nozzle rotation angle, deg	Configuration description	Notes Date
1	01.1000	01	14/(58)	52	1.3	399/(750)	90	BNS-1 baseline	Propulsion data no * good. Rpt run required 4-18-74
		02	14/(58)	52	1.4	427/(800)	90	7 lobes flowing	Full acoustic array
		03	14/(58)	52	1.5	454/(850)	90	A_{exit} = 92.4 in.^{2}	* Punched tape malfunction
		04	14/(58)	52	1.6	482/(900)	90	Exit P_T rakes on	Not salvageable
2	01.1000	01	NOT REQD	NOT REQD	1.3	399/(750)	90	BNS-1	Propulsion run only 4-19-74
		02			1.4	427/(800)	90	Exit P_T rakes on	
		03			1.5	454/(850)	90		
		04			1.6	482/(900)	90		
3	03.1001	01	13/(56)	56	1.3	399/(750)	90	BNS-3 convergent ends internal	Full MIC array 4-19-74
		02			1.4	427/(800)	90	Fairing installed	
		03			1.5	454/(850)	90	A_{exit} = 70 in.^{2}	
		04			1.6	482/(900)	90	No P_T exit rakes	
		05			1.7	510/(950)	90		
		06			1.5	454/(850)	90		Rerun of 1.5 and 1.4 for quick look
		07			1.4	427/(800)	90		4-19-74
					1.3	399/(750)	90	Inspection of plenum after shutdown revealed gasket section blew out (leak path)	

Delivered nozzle to fab shop (2nd shift) to install tone control secondary struts (these are side shields installed as nozzle wall extensions)

Reinstalled BNS-3 with struts—repaired blown gasket section at plenum—transition interface and replaced bolts 4-22-74

Table B-1. Test Log Continued

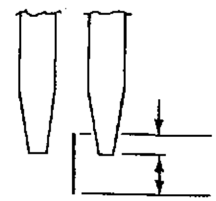
Run number	Config number	Condition number	Outside air temp °C/(°F)	Relative humidity (%)	Nozzle pressure ratio NPR	Exhaust gas temp °C/(°F)	Nozzle rotation angle, deg	Configuration description	Notes Date
4	03.1101	01	13/(56)	60	1.3	399/(750)	90	BNS-3 plain convergent	4-22-74
		02			1.4	427/(800)	90	1 in. secondary struts on no P_T exit rakes	
		03			1.5	454/(850)	90	Internal fairing installed	4-22-74
5	03.1101	01	13/(56)	61	1.3	399/(750)	90	Internal fairing installed plus 5 in. long struts	4-22-74
					1.4	427/(800)	90	Tone still evident	
					1.5	454/(850)	90		
Removed nozzle for modification at fab shop; installed fences in secondary									4-22-74
6	03.1101	01	9/(47.7)	80	1.3	399/(750)	90	BNS-3 with 5 in. fences in secondary with internal fairings	4-23-74
		02	9/(47.7)	80	1.4	427/(800)	90		
		03	9/(47.7)	80	1.5	454/(850)	90		
		04	9/(47.7)	80	1.6	482/(900)	90		
		05	9/(47.7)	80	1.7	510/(950)	90		
7		01			1.3	399/(750)	90	BNS-3 with 9 in. fences in secondary	4-23-74
		02			1.4	427/(800)	90	Single MIC on-line acoustics only (no performance data)	
		03			1.5	454/(850)	90		

Table B-1. Test Log Continued

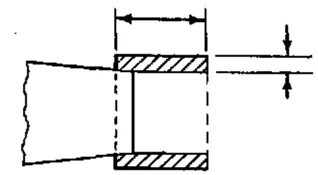
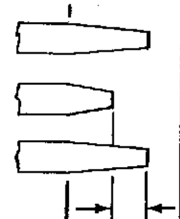
Run number	Config number	Condition number	Outside air temp °C/(°F)	Relative humidity %	Nozzle pressure ratio NPR	Exhaust gas temp °C/(°F)	Nozzle rotation angle, deg	Configuration description	Notes Date
	No runs on 4-24-74 because of bad weather—began adding vertical extensions to 5 in. long fences in secondary								
8		01	51°/10.5 10.5/(51)	68	1.3	399/(750)	90	BNS-3 plain conv. with vertical extensions to fences—height = 12.2 in.	4-25-74
		02			1.4	427/(800)	90	Full MIC array	(No exit rakes)
		03			1.5	454/(850)	90	Audible tone evident	
		04			1.6	482/(900)	90		
		05			1.7	510/(950)	90		
	Delivered nozzle to fab shop to cut back exits 1 in. on lobes nos. 2, 4, 6								
9		01	51°/ 10.5/(51)	81	1.3	399/(750)	90	BNS-3 plain conv with alternate lobe exits	4-26-74
		02			1.4	427/(800)	90	Cutback 1 in. (No exit rakes)	
		03			1.5	454/(850)	90	Full MIC array	
		04			1.6	482/(900)	90		4-26-74

Table B-1. Test Log Continued

Run number	Config number	Condition number	Outside air temp °C/(°F)	Relative humidity (%)	Nozzle pressure ratio NPR	Exhaust gas temp °C/(°F)	Nozzle rotation angle, deg	Configuration description	Notes Date
9 (cont)		05			1.7	510/(950)	90		
	Installed exit P_T rakes on lobes nos. 1 and 3								
10		01	10.5/(51)	81	1.3	399/(750)	90	Same as run 9 plus exit rakes	4-26-74
		02			1.4	427/(800)	90		Full acoustic array 4-26-74
		03			1.5	454/(850)	90		
		04			1.6	482/(900)	90		
		05			1.7	510/(950)	90		
	Removed exit rakes and internal strut fairings								
11		01	10.5/(51)	81	1.3	399/(750)	90	Same as run 9	4-26-74
		02			1.4	427/(800)	90	With internal strut fairings removed	
		03			1.5	454/(850)	90	(No exit rakes)	
		04			1.6	482/(900)	90		4-26-74
		05			1.7	510/(950)	90		
		06			1.8	510/(950)	90		
	Delivered nozzles to fab shop to install Corrugated nozzles								
12		01	10.5/(51)	70	1.3	399/(750)	90	BNS-3 corrugated lobes	4-30-74
		02			1.4	427/(800)	90	Internal strut fairing out	Wind 5-8 mph
		03			1.5	454/(850)	90	Full MIC array (No exit rakes)	
		04			1.6	482/(900)	90	No audible tones	

Table B-1. Test Log Concluded

Run number	Config number	Condition number	Outside air temp °C/(°F)	Relative humidity (%)	Nozzle pressure ratio NPR	Exhaust gas temp °C/(°F)	Nozzle rotation angle, deg	Configuration description	Notes Date
12 (cont)		05	10.5/(51)	70	1.7	510/(950)	90		
		06			1.8	510/(950)	90		
	Removed internal strut fairings								4-30-74
13		01	18/(64)	47	1.3	399/(750)	90	Same as run 12 with strut fairings <u>installed</u>	4-30-74
		02			1.4	427/(800)	90		Wind 5-15 mph
		03			1.5	454/(850)	90		
		04			1.6	482/(900)	90		
		05			1.7	510/(950)	90		
		06			1.8	510/(950)	90		
14		01	9/(48)	66	1.3	399/(750)	90	Repeat of run 13 with wind ‹5 mph	5-1-74
		02			1.4	427/(800)	90		
		03			1.5	454/(850)	90		
		04			1.6	482/(900)	90		
		05			1.7	510/(950)	90		
		06			1.8	510/(950)	90		

APPENDIX C

LAB/TEST REPORTS

PURPOSE OF TEST

Acoustic tests on the lobe-type jet suppressor nozzle of the Buffalo augmentor wing aircraft revealed a strong 2-kHz tone generated by the nozzle. The subject test was conducted to evaluate the effectiveness of several hardware modifications designed to suppress or eliminate the tone and to measure thrust and acoustic performance of a flight design. The test was conducted at the Hot Nozzle Test Facility using full scale hardware and hot flow.

TEST PLAN

Figure C-1 delineates the acoustic arena layout used for the 1/2-in. ground-mounted microphones. Acoustic data were recorded in the far field for the following hardware configurations:

Run	Configuration
1	Baseline nozzle BNS-1
3	Plain convergent nozzle BNS-3 with internal fairings
4	Same as no. 3 with 1 in. fence on nozzle edge
5	Same as no. 3 with 5 in. fence on nozzle edge
6	Same as no. 3 with 5 in. fence installed on ℄ of secondary air passage
7	Same as no. 6 with 9 in. fence
8	Same as no. 6 except fence extended 1 1/2 in. above and below lobe exit
9	Same as no. 3 with lobe 2, 4, 6 shortened 1 in. and no fence
10	Same as no. 9 with rakes installed
11	Plain convergent nozzle BNS-3 with staggered lobe ends and no fairings. Lobes 2, 4, 6 are 1 in. shorter than 1, 3, 5, 7
12	Corrugated convergent nozzle without fairings, BNS-3
13	Same as no. 12 except with fairings
14	Repeat of run no. 13

SYSTEM CALIBRATIONS

Two types of calibration are performed on the acquisition data system prior to recording test data. The first determines the frequency response of the microphone, preamplifier, cables, and signal-conditioning equipment. This is performed before and after each test, using the electrostatic actuator method illustrated in the block diagram (figure C-2). The sweep oscillator frequency is referenced to an electronic counter, certified and calibrated by the Boeing Flight Test Calibration Laboratory. The laboratory maintains test standards, references, and equipment with calibration accuracy traceable to the U.S. Bureau of Standards. When the frequency response of the system relative to 250 Hz has been determined, corrections are computed for each one-third octave band and applied to the data during reduction to obtain a uniform (flat) system response at all frequencies within the data bandwidth.

The second calibration is an end-to-end sensitivity check, performed each day before and after a test. An acoustic pistonphone calibrator, with a constant known SPL at 250 Hz, is applied to each microphone, and the calibrator signal is recorded on magnetic tape. This reference is used during the data reduction process to determine system sensitivity. The device used, a Bruel & Kjaer (B&K) model 4220 pistonphone, has a certification traceable to the U.S. Bureau of Standards through a secondary standard maintained by the Boeing Metrology Laboratory.

The tape recorder and reproducer are not included in frequency response calibrations performed in the field. The tape machines, tested and certified by the Boeing Flight Test Laboratory, have a flat frequency response from dc to 10 kHz when operated in the FM mode at 30 in./sec.

DATA ACQUISITION PROCEDURES

The signal conditioning and recording instrumentation used for noise data acquisition are described in tables C-1, C-2, and C-3 and figures C-3 and C-4.

Data are recorded with the microphones placed in their windscreens in an inverted position over a smooth concrete surface with the diaphragm 1/2 in. above and parallel to the ground plane.

Each microphone is calibrated to determine its sensitivity and then placed in the 50-ft polar location that is to be used for data acquisition. The noise floor of each channel is then determined and recordings made prior to the engine test runs. The noise floor of the B&K 1/2-in. microphone

TABLE C-1

Test point	Location	Height feet	T/R chan. no.– sw pos no.	MIC type	Serial no.	Comments
9	09050FP	0.5 in.	2A-1	4134	142647	W/grid inverted
10	10050FP		2A-2		245005	0.5 in. above
11	11050FP		2A-3		258526	surface
4	11550FP		2A-4		258547	
13	12050FP		2A-5		402665	
5	12550FP		2A-6		402752	
14	13050FP		2A-7		456186	
6	13550FP		2A-8		456203	
15	14050FP	0.5 in.	2A-9	4134	456279	

TABLE C-2

Test point	Transducer		Preamp		Power supply		Dynagage	Termination	Line-amp dynamics
	Type	Serial no.	Type	Serial no.	Type	Serial no.	BC no.	BC no.	BC no.
9	4134	142647	1560-P42	571	Harrison 6366A	BC351275	n.a.	n.a.	n.a.
10		245005		550					
11		258526		668					
4		258547		595					
13		402665		667					
5		402752		228					
14		456186		815					
6		456203		528					
15	4134	456279	1560-P42	633					

TABLE C-3

Channel	System no. 1 dynamics rack BC 349136 dynamics plug-in	System no. 2 dynamics rack BC dynamics plug-in	Tape system T/R Ampex FR1800 BC 355703-1		Mode
			Record	Reproduce	
1	351546-16	n.a.	X876233	X878974	FM
2	351546-14		X876228	X880168	
3	351543-13		X883344	X876246	
4	355354-15		X876230	X876240	
5	351543-8		X876227	X879260	
6	348226		X876224	X876742	
7	351513-8		X876226	X880158	
8	351544-15		X876229	X876235	
9	3515447		X876231	X876245	
10	351543-14		X880039	X883343	
11	351517-10		X155742	X883342	
12	351515-9		X877355	X880169	
13	351513-6		X879243	X876846	
14	351544-12	n.a.	X880090	X876238	FM

systems used for this test is on the order of 10 to 15 V electrical output, equivalent to 32 to 37 dB SPL overall. The recorded noise floor, however, contains both electrical noise and acoustic ambient background noise. The latter usually dominates the noise floor recordings at frequencies below 100 Hz.

Data recordings are made for 16 sec during a stabilized nozzle pressure ratio setting. The tape-recorded sample includes voice identification and an IRIG 'B' time code reference on track 14. A written tape log includes:

1. Run identification
2. Gain settings used for recording each condition
3. Time code at the start of the recording
4. Equivalent SPL of the calibration signal
5. Date, engineer, and serial numbers of recording equipment and microphones

ACOUSTIC DATA REDUCTION PROCEDURE

Acoustic data recorded on 14-track analog tape is reproduced and analyzed in one-third octave bands at acoustic laboratory facilities in Seattle, Washington. The basic analysis system consists of an analog tape reproducer, General Radio Model 1921 one-third octave analyzer, time code reader, PDP8-I computer, digital magnetic tape recorder, and associated monitor, control, interface, and peripheral service equipment (fig. C-5).

The operator controls the analysis through a teletype keyboard used for entering calibration, frequency response compensation, and measurement point identification information into the computer. The General Radio analyzer includes a bank of 24 one-third octave-band filters, covering the frequency range of 50 to 10 kHz. The filters meet International Standard IEC 225 and USA Standard 51.11-1966 Class III requirements and are calibrated with both sine wave and random noise inputs. The true rms detector section of the analyzer has a dynamic range of 60 dB and a resolution of $\pm$0.25 dB. The square law response of the detector is verified by the two sinewave insert method per IEC 179, para. 8.5. Frequency response compensation and sensitivity calibration information are added to the one-third octave-band data in the computer and output on a digital magnetic tape in a format compatible with existing CDC-6600 computer software. All components of the reduction system are periodically certified to manufacturer's specifications by the Boeing Flight Test Calibration Laboratory.

DATA TRANSMITTED:

The following data were analyzed and transmitted to ANS:

1. 864 one-third octave-band spectrum plots on May 15, 1974.
2. Digital magnetic tape 66R851 containing the above one-third octave data was filed in the Renton 6600 tape library.
3. 18 narrow-band spectrum plots of four pressure ratios at the 115° polar microphone position, for each run. These plots were provided as quick-look data during the test period from April 18, 1974 to May 1, 1974.

The spectrum plots include reference nozzle runs obtained by blowing cold air through a 4 in. round convergent nozzle at a pressure ratio of 2.5. The noise field produced is recorded as an

acoustic reference before and after each data run. Comparison of these spectra enables the data analyst to determine the consistency of the acoustic arena environment as well as the repeatability of the acquisition system. A sample spectrum is shown in figure C-6. A second reference used is random (USASI) noise electrically inserted into the signal conditioning and recording portion of the acquisition system. These spectra should be repeatable on any one channel (test point) within ± 1.0 dB between 50 and 10 kHz. A sample spectrum is shown in figure C-7.

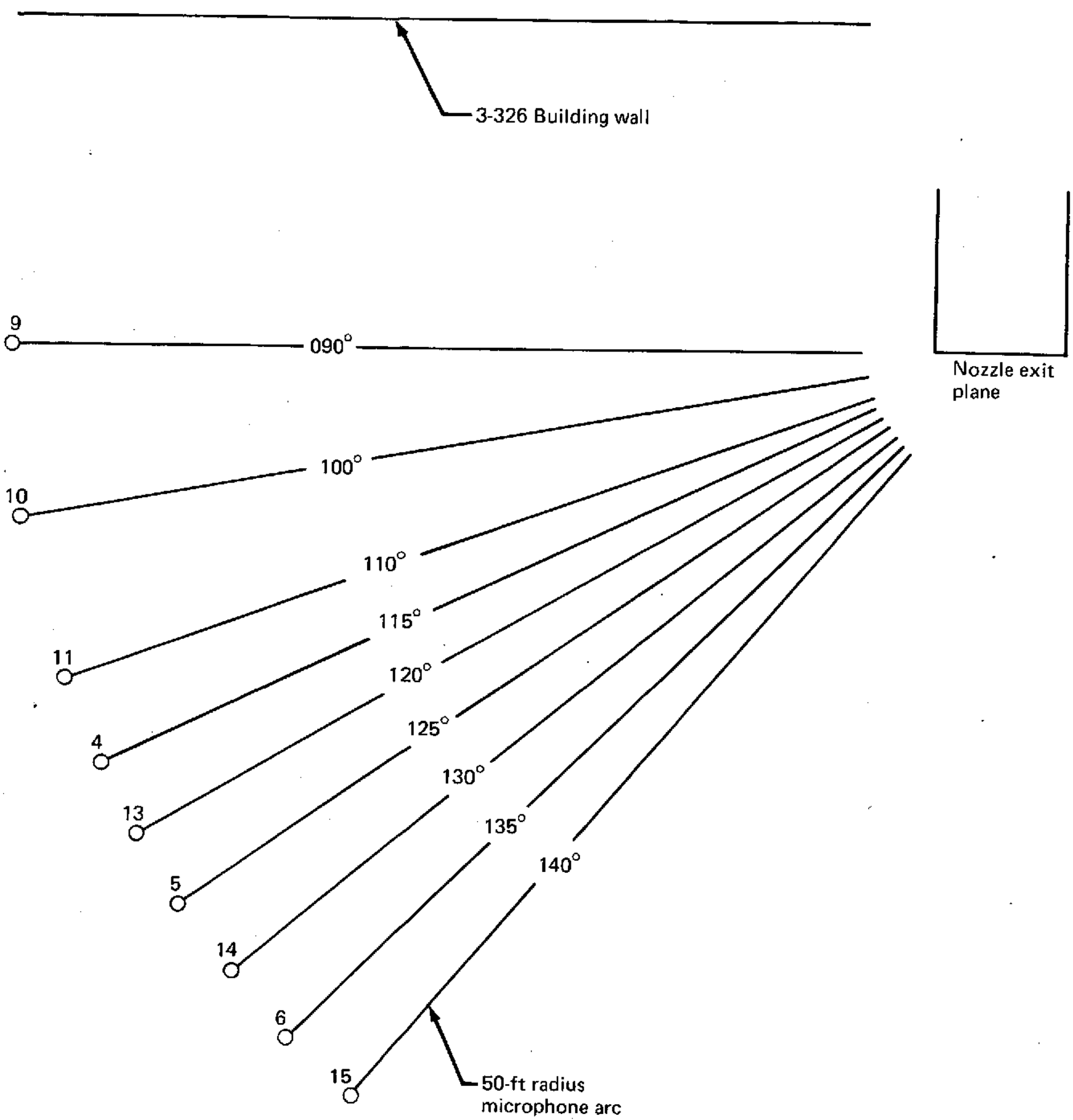


FIGURE C-1.—TEST ARENA—BUFFALO SUPPRESSOR NOZZLE AND TONE TEST NO. 2

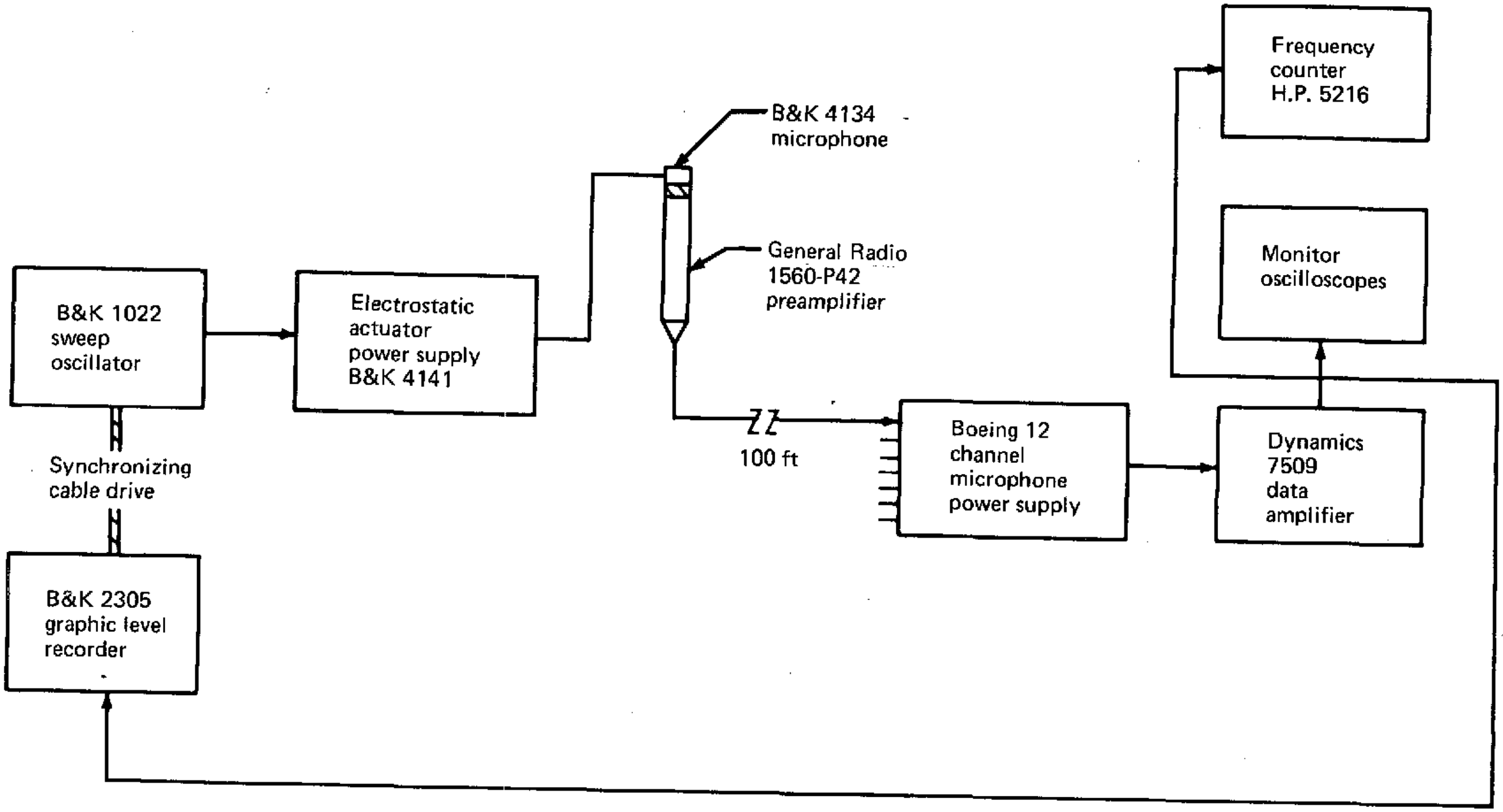


FIGURE C-2.—DATA ACQUISITION SYSTEM CALIBRATION SCHEMATIC

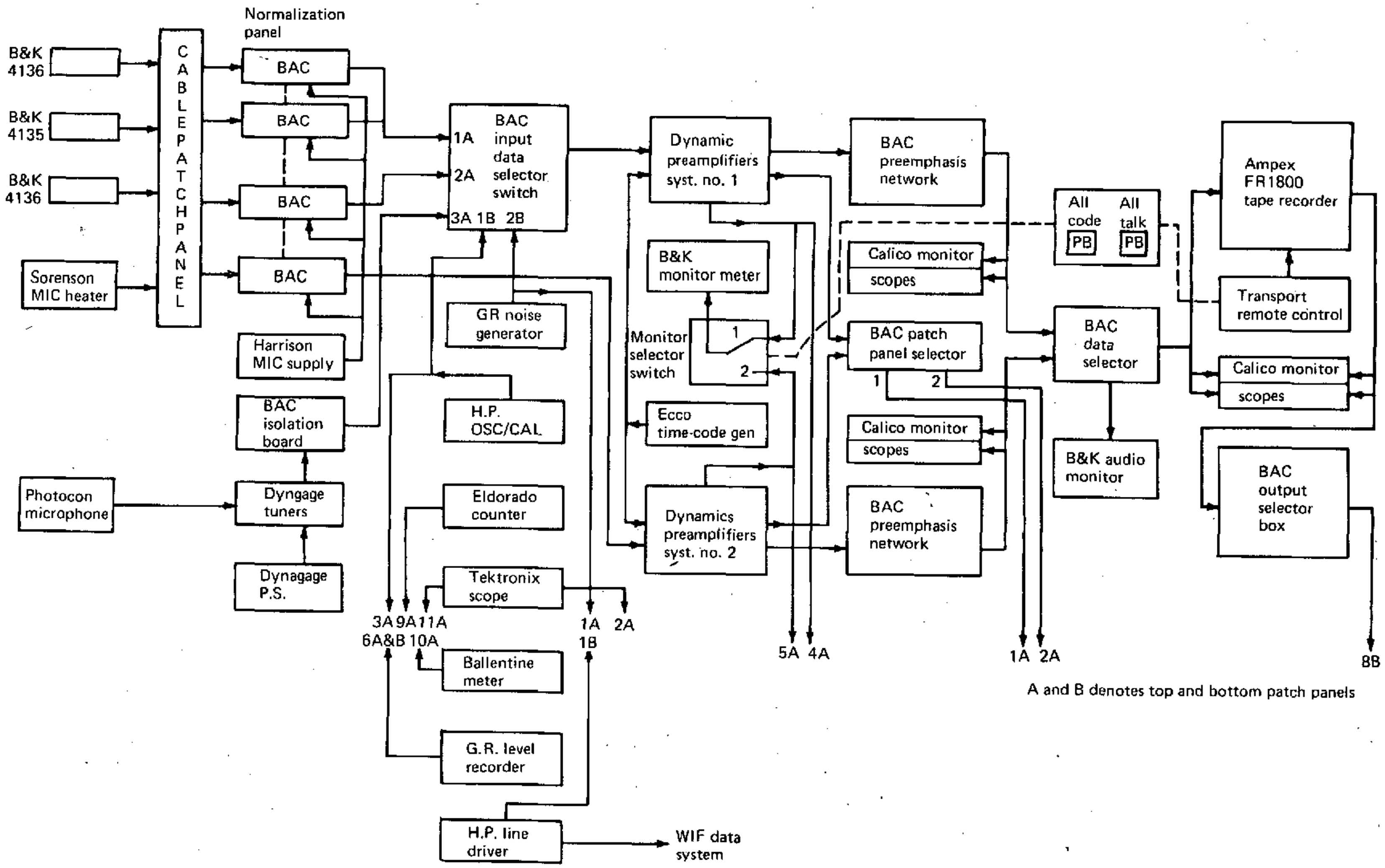


FIGURE C-3.–BLOCK DIAGRAM ACOUSTICS DATA ACQUISITION SYSTEM HNTF N.B.F.

Quantity	Item	Mfg/model	BC no.
1	Meter, VTVM, monitor	B&K 2416	525520
6	Scope, monitor record/ reproduce	Calico 7000	349156
			349624
			349625
			349627
			351509-24
			351509-25
1	Meter, VTVM, calibration	Ballentine 323-08	362147
1	Scope, calibration	Teletronix RM503	347096
1	Counter	Eldorado 1000B	352183
1	Generator, RF	H-D 651B	351513-18
1	Generator, random noise	Gen radio 1382	368551
1	Power supply, mic heater	Sorenson QR040-4A	35133
2	Preemphasis network	BAC	365562
		BAC	365563
1	Voltage regulator	Gen radio 1570AL	185339
1	Psychrometer	Bendix 566	V883297
1	Calibrator, piston phone	B&K 4220	186829
1	Graphic level recorder		
	frame and paper drive	Gen radio 1523	369259
2	One-third octave plug in	Gen radio 1523-P3	369260
1	Data input selector panel	BAC	351513-20
1	Time code generator	ECCO 858A	351513-13

FIGURE C.4—BLOCK DIAGRAM-ACOUSTICS DATA ACQUISITION SYSTEM HNTF M.B.F.

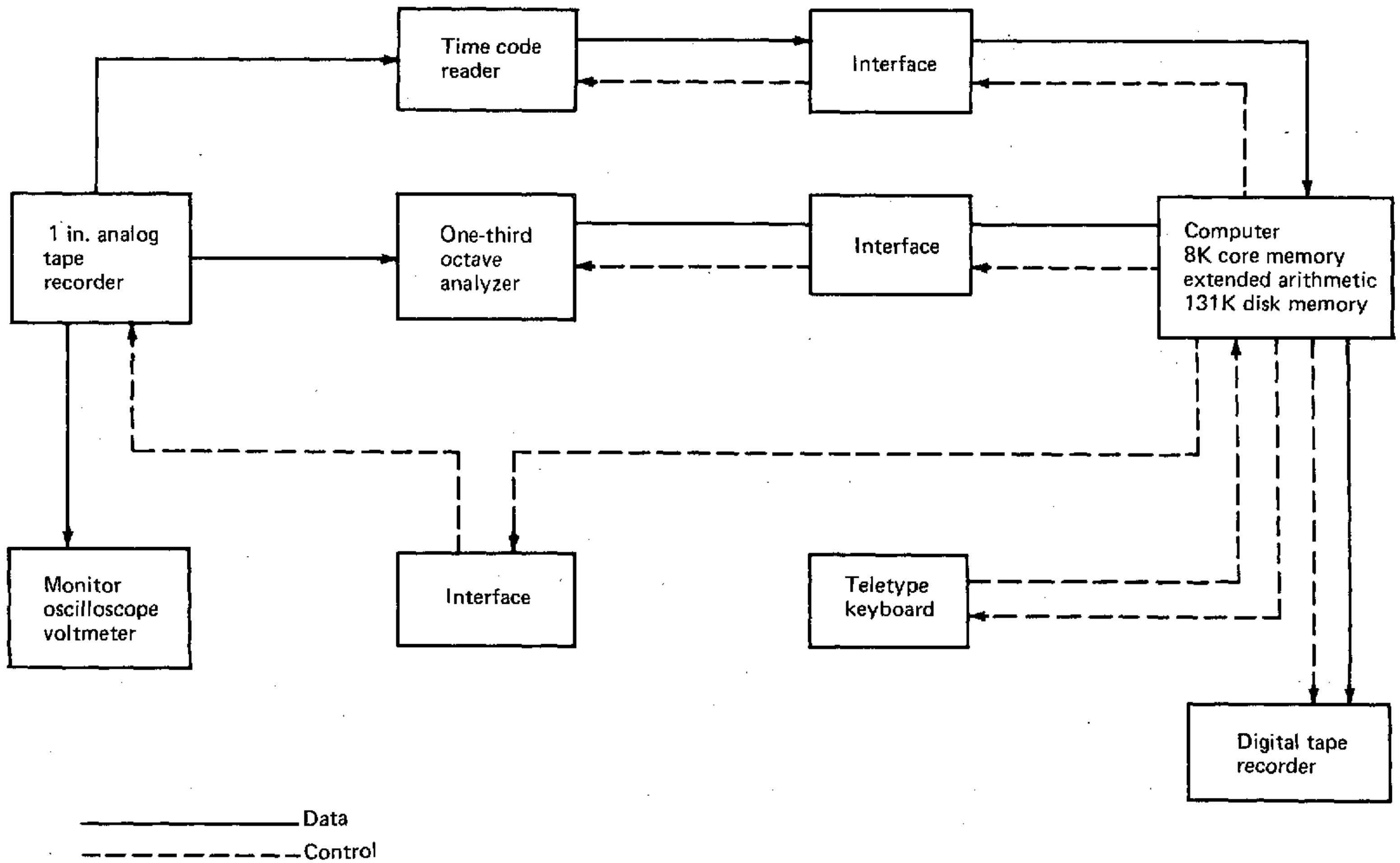
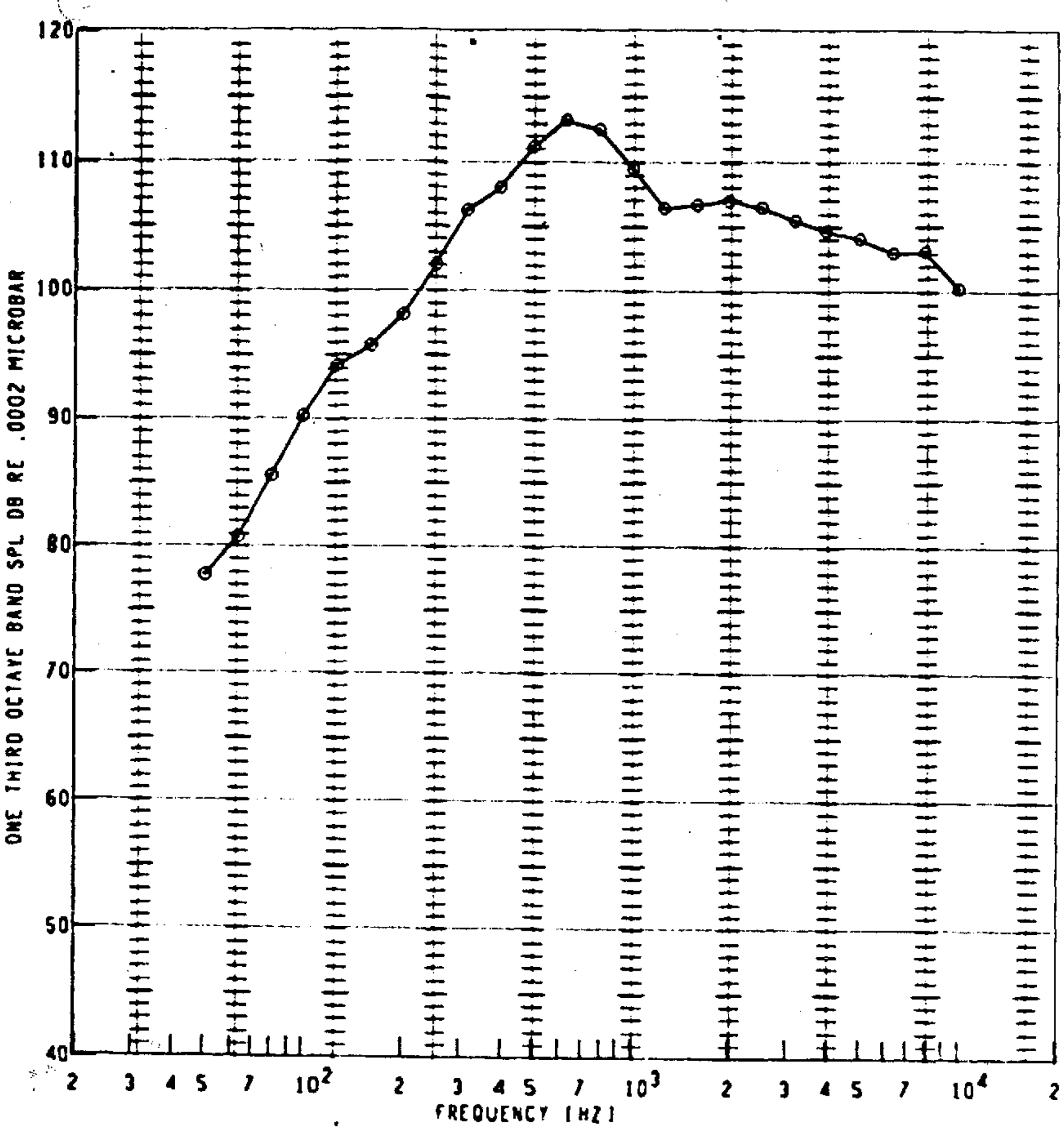


FIGURE C-5.—ACOUSTIC DATA REDUCTION SYSTEM

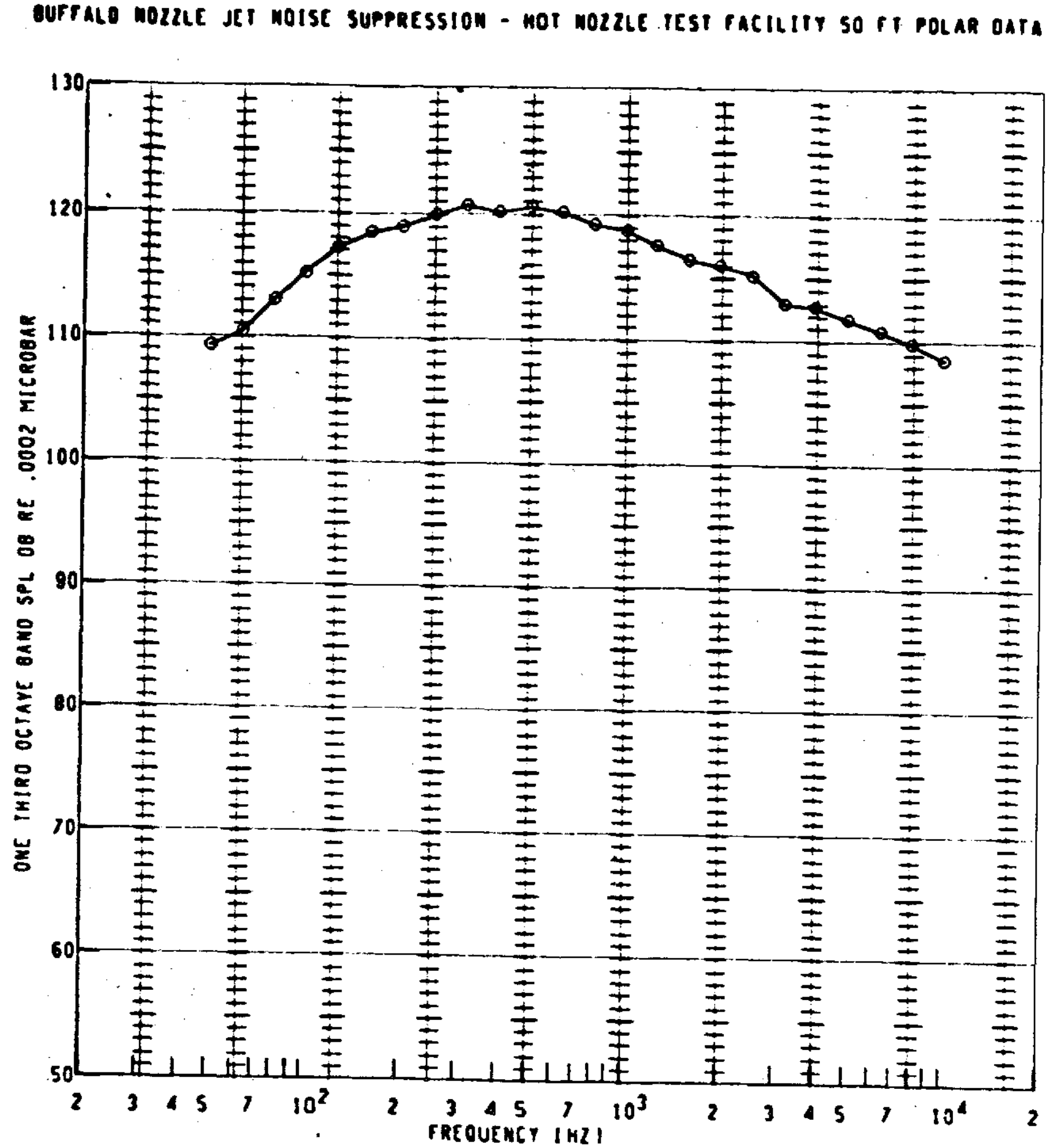
BUFFALO NOZZLE JET NOISE SUPPRESSION - HOT NOZZLE TEST FACILITY 50 FT POLAR DATA



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊖	R004	-0	2.500	135G	50FP	120.5	0	REF NOZZLE

FIGURE C-6.—DATA ACQUISITION SYSTEM CALIBRATION SCHEMATIC

4 Inch Conical Reference Nozzle Spectrum For 135° Polar Microphone



PLOT SYMBOL	RUN NUMBER		PRESSURE RATIO	ANGLE RE INLET	MIC LOCATION	OASPL (DB)	GAIN SETTING	SPECIAL ID
⊙	S007	-0	*.000	135G	SOFP	130.7	0	USAS NOISE

FIGURE C-7.—ACOUSTIC DATA REDUCTION SYSTEM

USASI Random Noise Insert Spectrum For
135° Data Channel

APPENDIX D

FLIGHT NOZZLE DESIGN SUMMARY

DESIGN SUMMARY

An investigation was made to determine the feasibility of designing and manufacturing a workable noise suppression nozzle for the Buffalo/Spey augmented wing airplane. Three nozzle configurations were considered: 15-lobe, 13-lobe and 11-lobe. The 15-lobe configuration is desirable for maximum noise suppression, while the 11-lobe configuration is desirable for maximum economy of manufacturing. Preliminary loft lines were drawn up for the 15-lobe version. This configuration required four different lobes for the nozzle assembly and would have required fourteen sets of tools to form the lobes. Casting was also considered with the possibility of chem-milling from the minimum cast wall thickness of 0.08, 0.09 in. to a desired wall thickness of approximately 0.040 in. in order to reduce weight. Manufacturing however, has no substantiating records demonstrating chem-milling of the candidate nozzle materials. Also, these alloys have a tendency to become passivated and inhibit the chem-milling process.

Following this investigation, the design effort was directed to developing a 13-lobe nozzle configuration that would eliminate ten of the fourteen sets of tools required to form the lobes.

The mounting ring which is part of the nozzle and a Bristol-Siddeley designed part is described on Bristol Siddeley Drawing No. B306652. The material is a Bristol-Siddeley alloy BSEM660, which is comparable to incolloy 901 and can be welded to adjoining nozzle materials.

MATERIALS

Five materials were investigated as candidate materials for the nozzle. These are 18-8 stainless steel (321 or 347), Hastalloy-X, Inconel 625, Haynes Alloy 188, and Inconel 718. The 18-8 stainless was eliminated because of low yield strength at the working temperature of the nozzle (1100°F). The Hastalloy X was eliminated because of previous problems encountered in welding sheets of the same material but of different melts. The Inconel 718 alloy was eliminated because of the high yield strength that would create difficulties in obtaining well-formed sheet metal parts where close fits are required for subsequent welding operations.

This left Inconel 625 and Haynes alloy 188. The Inconel 625 was readily available from a Los Angeles warehouse (5 to 10 days delivery time). The Inconel 625 and Haynes 188 alloys exhibit respectable yield strengths and elongation for the environmental conditions encountered by the nozzle. The Inconel 718 was considered for casting purposes. A tabulation of the candidate materials is shown as follows on Table D-1.

A set of drawings from which the nozzle was to be manufactured were partially completed. Figure 9, in the summary, shows the final geometrical layout of the nozzle.

TABLE D-1.—CANDIDATE ALLOYS

	A1S1 (321)-(347)		Hastalloy X		Inconel 625		Haynes 183		Inconel 718	
Work	RT	1100°F	RT	1100°F	RT	1100°F	RT	1100°F	RT	1100°F
F_{tu}KS1	75	49.5	100	76	120	98	137	106	135	153
F_{ty}KS1	30	12.6	45	31.2	60	40	68	44	133*	132
E_{x10^6}	29	23.2	29	23.2	29	23			29	23.5
$T_{(exp)}$		1.1%		0.88%		0.8%				0.83%
Elongation	40%		35%		60%		61%	73%	22%	

*The high yield point of Inconel 718 presents difficulties with respect to sheet metal forming when considering only six nozzles